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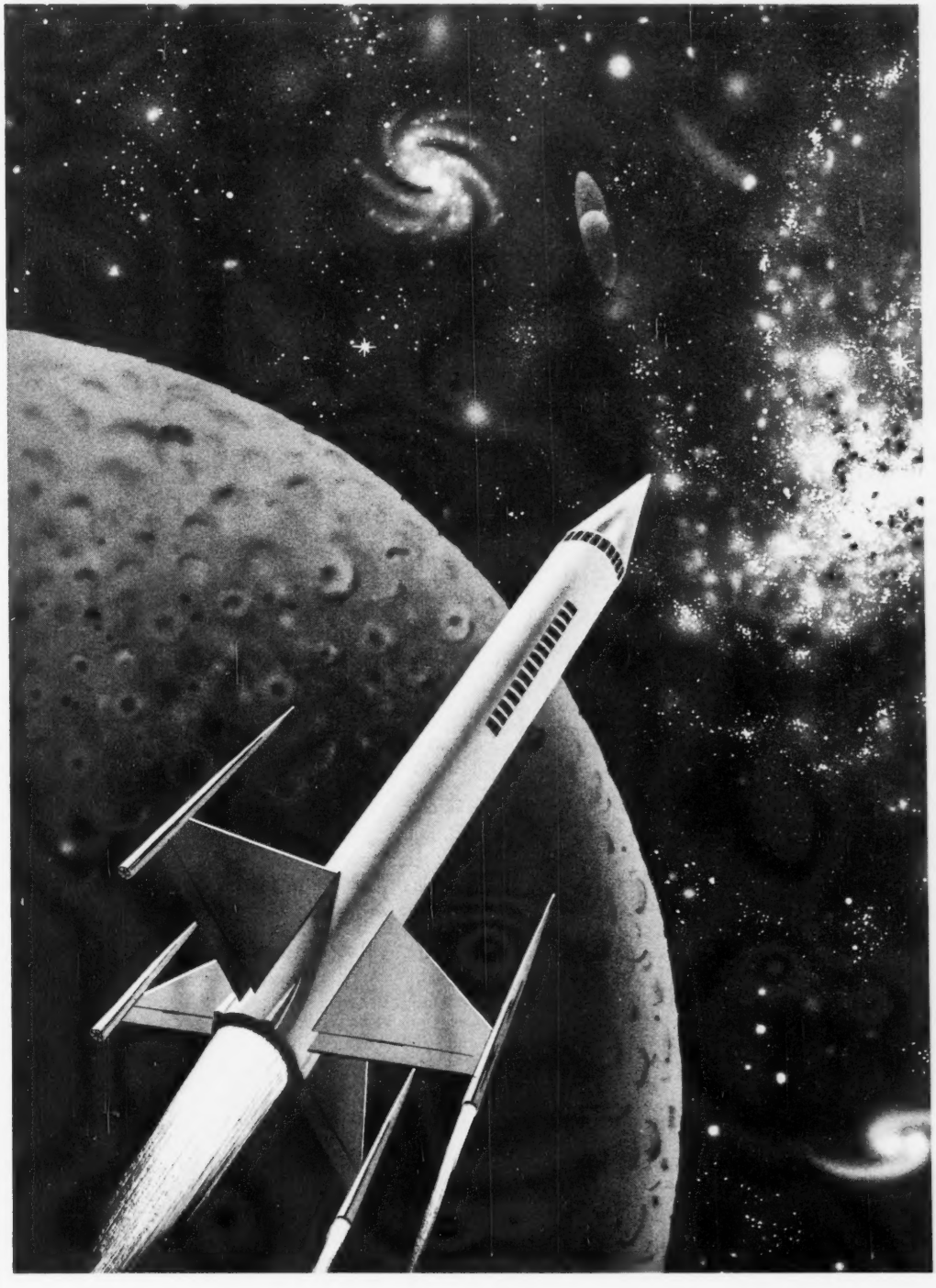

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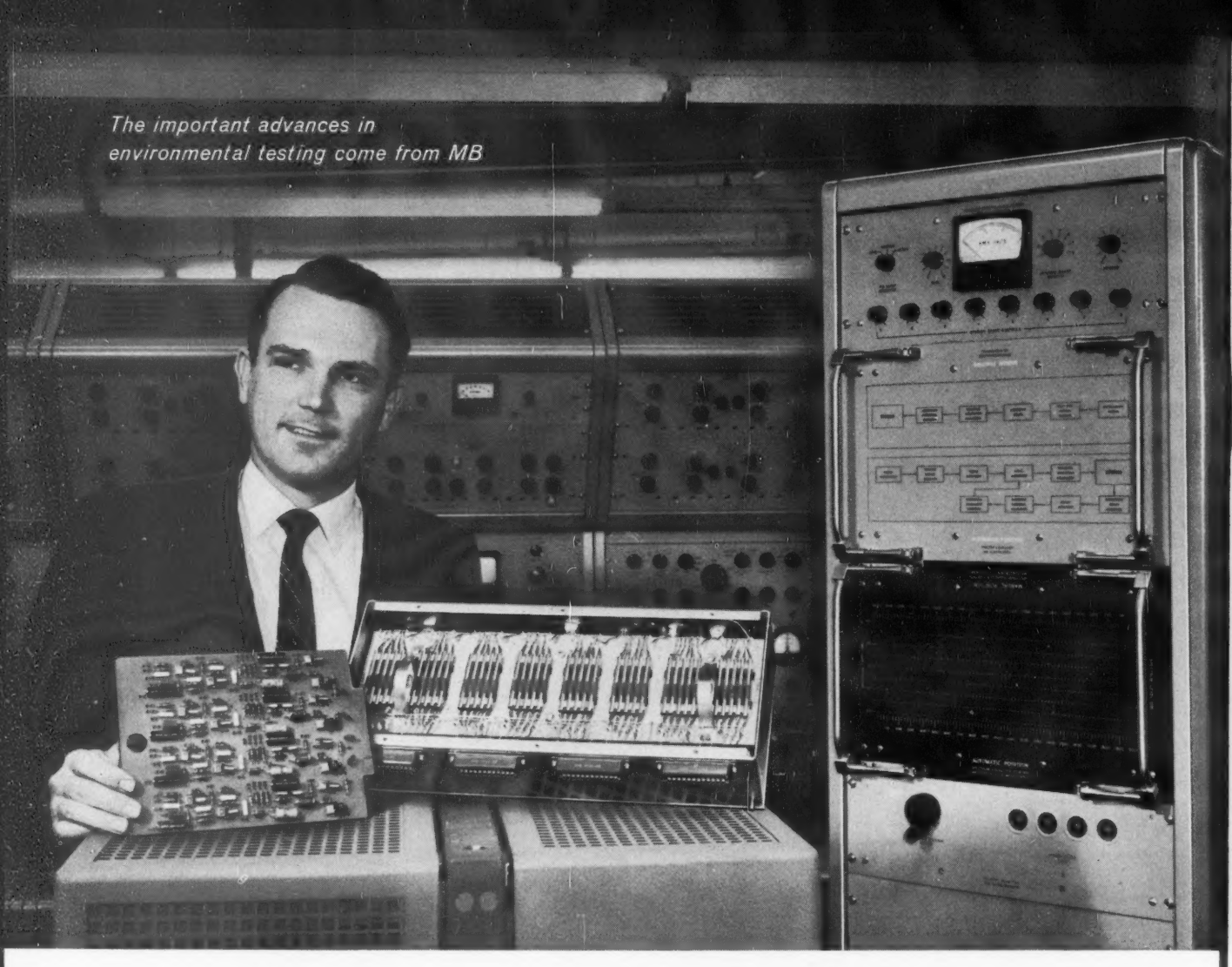

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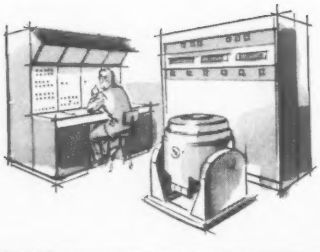

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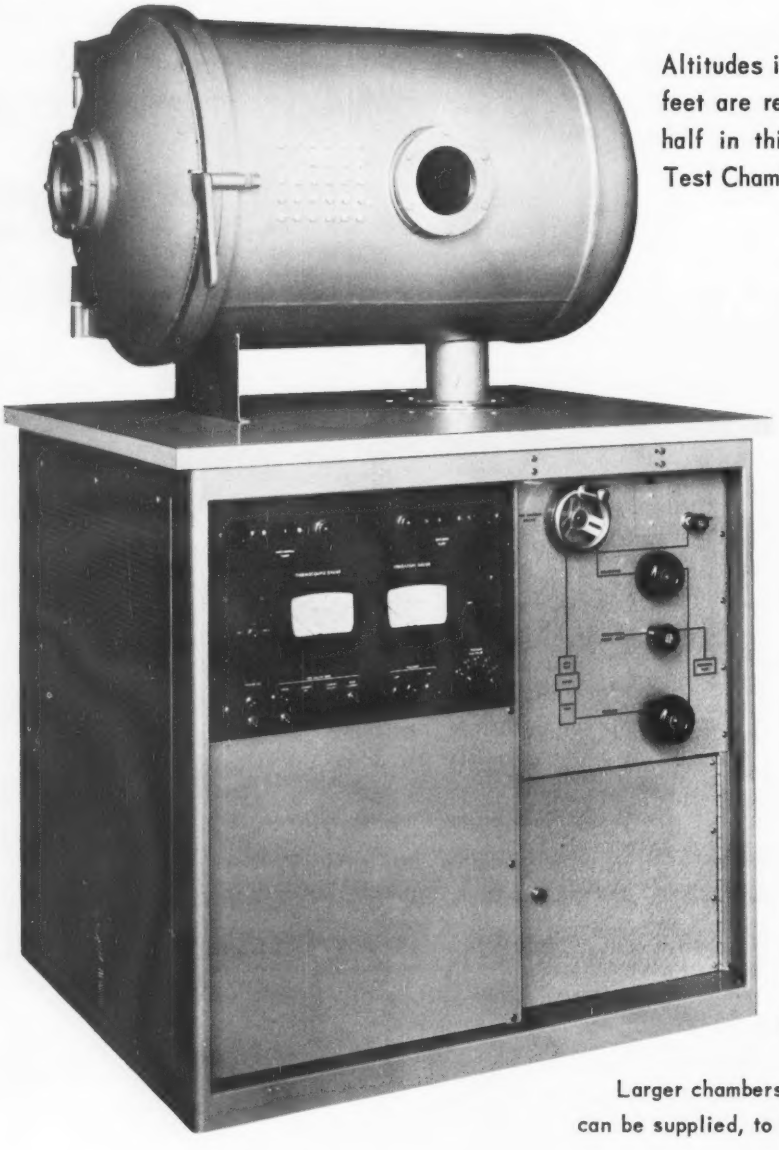

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VOLUME 3 NUMBER 4

the JOURNAL of environmental sciences

For active Environmental Engineers and the executives throughout industry who are concerned with the advancement of Environmental Engineering by the Institute of Environmental Sciences.

Charles W. Danielson, Technical Editor

Robert Whiting, Associate Editor

AUGUST 1960

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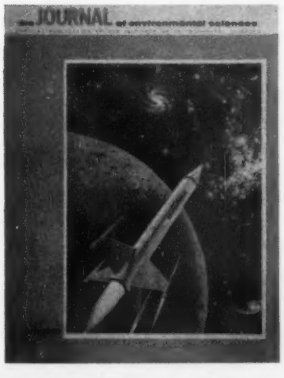

This Month's Cover Theme is "Ultra High Vacuum"

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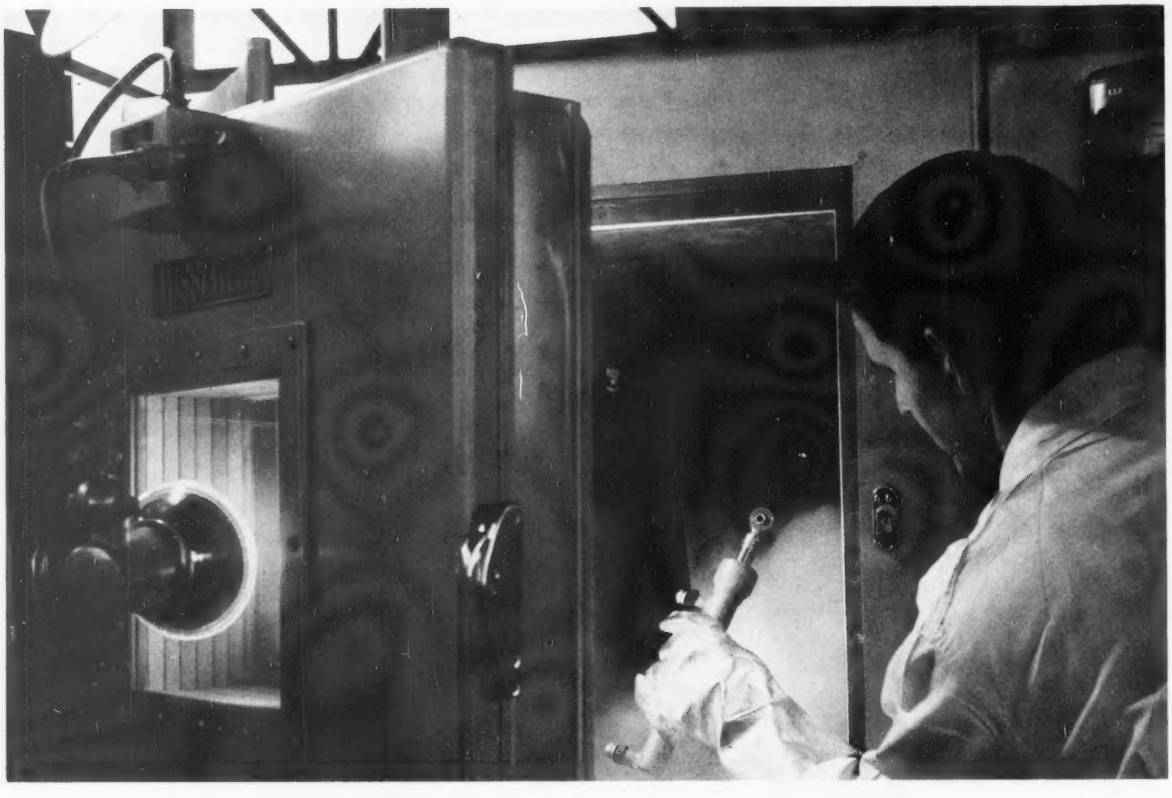

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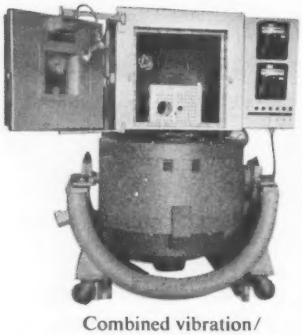

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VACUUM TANK FOR CONTAINER TESTING

By D. Stern
Vibration and Stress Analysis Engineer
Armament and Control Section
Light Military Electronics Department
GENERAL ELECTRIC COMPANY
Johnson City, New York

BIOGRAPHY OF DANIEL STERN

Mr. Stern received a B.M.E. degree from New York University in 1951 and an M.S. in M.E. degree from the University of Maryland in 1957. He was a marine engineer with the Navy Department Bureau of Ships from 1951 to 1953 and served in the U.S. Army as a guided missile technician from 1953 to 1955. He then went with the Naval Ordnance Lab as a mechanical engineer doing vibration test and design until joining the General Electric Company in Johnson City, N.Y., in September 1959 where he is a vibration and stress analysis engineer.

Mr. Stern is a member of A.S.M.E. and S.A.E.; and has a patent for a safety shutoff coupling.

The work described in this article was performed while the author was employed at the Naval Ordnance Laboratory.

ABSTRACT

This article outlines the construction and testing techniques employed in building and using a vacuum tank for container leak-testing. The method simplifies the problem of leak testing large containers.

VACUUM TANK FOR CONTAINER TESTING

The problem of leak-testing large metal containers at the Naval Ordnance Laboratory, Silver Spring, Maryland, has been simplified by the construction of a vacuum tank. The testing technique consists of evacuating the air space above a submerged container. Leaks in the container are indicated visually by the emission of air bubbles.

A tank was fabricated from 3/4 inch thick hull plate; SAE 1035. The inside tank dimensions were 30½ inches by 30½ inches by 41 inches. Instead of machining, the plates were flame-cut to size and the edges flame-chamfered ¼ inch by 45°. Window openings 11 inches by 20 inches in three of the side plates were also cut with a torch. The plates were then tacked together, and arc-welded on the outside corners. The first pass was with a 3/16 inch diameter AWS rod No. 6010. For the remaining passes, a ¼ inch diameter AWS rod No. 6020 was used. A light sealing bead was put on all inside corners. Four ½ inch by 12 inch by 21 inch steel bars were arc-welded diagonally across the top of the cover as braces.

Three one inch by 12 inch by 21 inch windows, which were rejected for wind tunnel use, were used on three sides of the tank. The window edges were covered with 1/16 inch thick white gum rubber, and sealed in Permatex No. 1. To provide better seating, the mating surfaces of the tank and cover, and the support surfaces for the windows were end-milled after the tank was welded, see Fig. 1. The window frames were made from No. 10 gage sheet steel. A 1/16 inch thick white gum rubber gasket was cemented on the machined surface of the cover with Pliobond.

To induce a vacuum, a surplus steam ejector was obtained; C.H. Wheeler No. 30390. The ejector was designed to operate on 80 psig steam for a Soloshell low pressure distilling unit. Although designed for use with steam, in this application, the ejector operates with 100 to 120 psig air. The ejector has been able to evacuate the empty tank to 27 inches of mercury in 3½ minutes. In the design stage, there was concern over the deflection of the plates that support the windows. The tank was designed to limit the deflections at the center of the windows to 0.050 inches at a load of 15 psi. Actual deflections, see Table 1, indicated that the deflections were well within this limit.

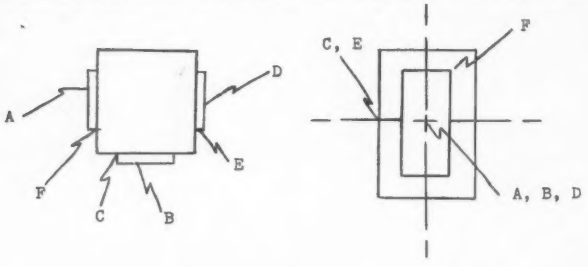
The empty tank with cover and windows, weighs 1533 pounds. When the tank is completely filled with water, the total weight is 3,000 pounds. The tank can be completely filled and then drained of water in 15 and 10 minutes, respectively. The tank was illuminated by two 30 watt fluorescent lights encased in polystyrene tubes. The fluorescent lights, shown in Fig. 2, have been replaced with two Crouse-Hinds type RCD-8 lighting fixtures, Form F. No. 41427B.

In operation, the tank is first filled with water. A container is then either held underwater or supported by a net, see Fig. 2. The cover is then placed on top. The surface between the cover and the tank is coated with Dow Corning high vacuum grease. The vacuum valve to the ejector is closed and the air pressure valve is opened. The vacuum is read on a mercury manometer, and the air pressure and vacuum valves are closed when the desired vacuum is reached. The manometer has both inch and millimeter scales. Most containers are tested down to 11 inches of mercury. The container can be observed through the windows and photographs taken, if so desired. To relieve the vacuum, the vacuum valve is opened. The system works quite rapidly and requires little maintenance.

Table 1. Deflections in inches for various locations.

Vacuum in.-Hg	A	B	C	D	E	F
0"	0	0	0	0	0	0
10"	.011	.009	.004	.012	.006	.009
20"	.023	.019	.007	.023	.011	.017
25"	.030	.021	.009	.027	.013	.022
27"	.032	.027	.010	.029	.014	.024

TABLE 1.
Deflections in Inches for Various Locations



Note: A,B, and D were on the windows. C,E, and F were on the milled surface adjacent to the windows. Deflections measured with 0.001 inch dial indicators.

FIGURE 1. End Milling Tank Top

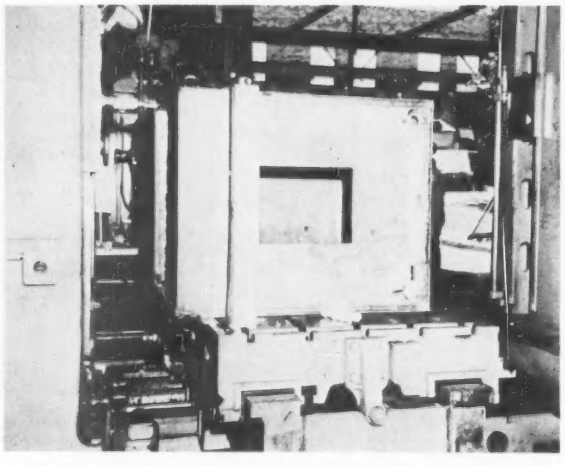


FIGURE 3. Top View With Cover Removed

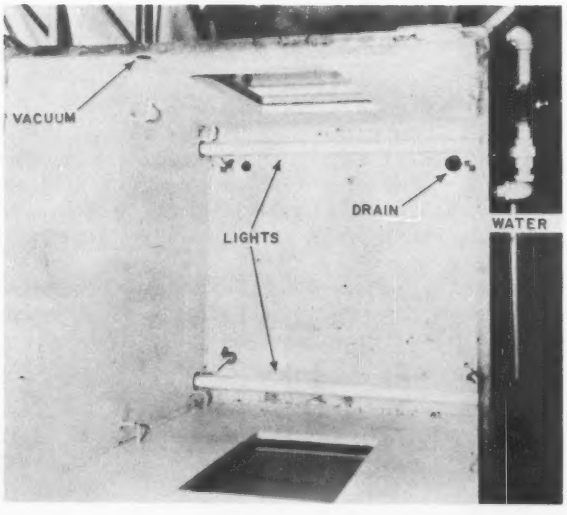
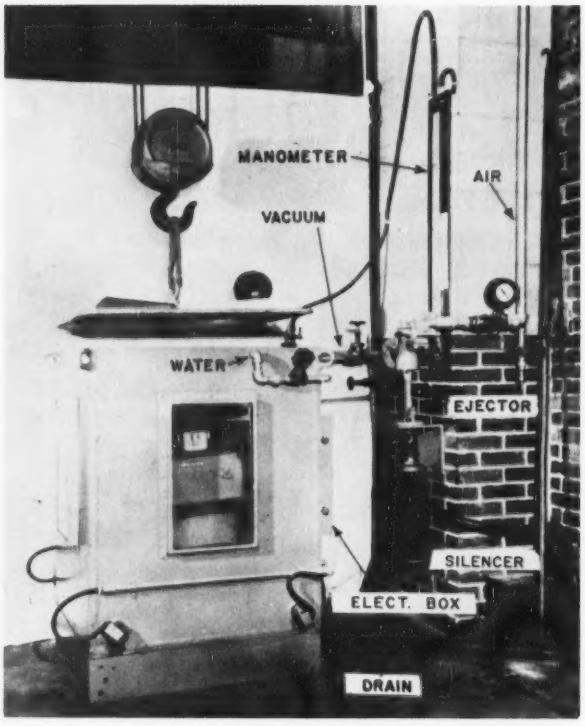


FIGURE 2. Front View of Tank



In last month's issue on page 22 a symbol was ommitted from formulas in the article "Development of a Combined Climatic, Static, and Dynamic Environmental Test Facility."

A corrected reprint of that portion of the article appears below.

The spring constant of the pneumatic spring is

$$k = \frac{\Delta F}{\Delta I} = \frac{A\Delta P}{\Delta V/A} = \frac{\Delta P}{\Delta V} A^2 = -\frac{Pn}{V} A^2$$

$$= -\frac{Pn}{IA} A^2 = -\frac{PnA}{I}$$

and referencing to mean pressure and clearance,

$$k = \frac{P_o n A}{I_o}$$

For the range of audio frequencies, an adiabatic process may be assumed. This assumption also applies, without serious error, in the range of frequencies to 5 cps. employing a value of n = 1.4, an expression useful for design purposes, from the above derivation, is as follows:

$$\frac{k}{m} = 1.4 \frac{P_o A}{M I_o} = \frac{1.4}{I_o} \cdot \frac{4\pi^2}{3600} \cdot R(RPM)^2$$

A SYNOPSIS OF NATURAL ENVIRONMENTS TO HEIGHTS OF 1000 Km

by A. P. HARRIS and E. W. PARROT

(Concluded from the June Issue)

The temperature of objects placed in space above this level are determined almost solely by the energy of the solar radiation received, the type of surface and the balance between absorption and re–radiation of radiant energy.
(References 2, 10, 11, 16, 17, 20, 22, 26, 33).

C.1.4 PRESSURE AND DENSITY

The pressure and density in terms of actual particles present and weights and pressures involved are shown in Fig. 10.

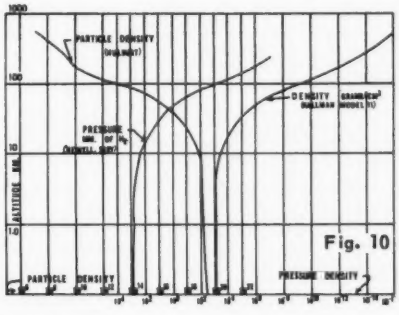


Fig. 10

The pressure in m/m of mercury drops by 5 orders of magnitude from 10 Km to 100 Km and probably by another 9 orders by the time 1000 Km is reached.

The density in grams per square centimeter at 10 Km is about 6½ orders down from 1 Km and drops another 8 orders or thereabouts at 1000 Km.

The actual number of particles (air molecular) present at 100 Km is about one millionth of what it was at sea level.

This means in more practical terms, that normal breathing becomes impractical after 16 Km, fuels will not burn much after 21 Km, aerodynamic lift is lost between 80 and 110 Km and thermal problems and rain air effects largely disappear between 160 and 180 Km. *(Ref. Buettner and Hober "The Aeropause" Science 115, 1952).*

The relationship and interdependence of pressures and densities on temperature, constituents and gravity needs no explanation here.
(Reference 7, 11, 18).

C.2 OZONE

It is theorized that Ozone is formed in the atmosphere by the action of sunlight on molecules of oxygen in the presence of other air particles.

Oxygen is dissociated to O by the action of ultra–violet light. Atomic oxygen combines with molecular oxygen in the presence of another air particle to form ozone.

The distribution of ozone with height is shown in Fig. 11.

The units here are centimeters per kilometer or the equivalent thickness, in centimeters, of Ozone in a kilometer of atmosphere when the ozone is compressed at normal pressure and zero degrees centigrade.

The peak occurs at about 21 Km. The two curves are representative of the maximum and minimum concentrations and encompass the results of a particular series of measurements.

The altitude of peak occurrence is not constant and varies with the season of the year between 17 and 24 Km. The concentration is highest during the winter months.

The actual particle concentration deduced *(Ref. 11)* is shown in the top curve and varies from about 5×10^6 particles per c.c. at 90 Km to about 8×10^{12} particles per c.c. at 30 Km.

At sea level the ozone concentration is very small and in the order of .001 cm. per Km. There is at sea level a daily variation in this concentration running as high as 6 to 1.

Ozone has some interesting properties. It is highly absorptive to high frequency sunlight and in fact cuts off from the earth most radiation less than 2550 Angstrom units in length. A reduction in the total atmosphere ozone by 1/3 would cause blistering of human skin. If doubled one of the controlling factors in formation of bacteria and fungus would be lost:

Ozone concentrations of the value occuring at 21 Km are toxic.

Ozone is therefore directly related to at least two other environments, surface solar radiation and fungus and bacteria.

The presence of the ozone layer is said to result in the increased air temperature occuring at about 50 Km.
(Reference 8, 11, 14, 21).

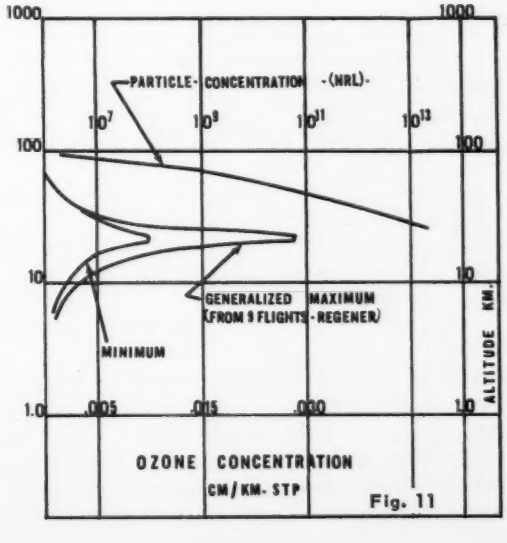


Fig. 11

C.3 MOISTURE VAPOUR

Moisture Vapour is a gaseous form of water, which forms over bodies of water and which is a common constituent of the atmosphere over most of the earth's surface.

The ability of the air to hold moisture depends directly on its temperature. This ability doubles with every 18°C increase in temperature. Because of this, the absolute humidity, which is the weight of actual vapour in a given volume of air, is greatest in warm climatic and lowest in cold. The arctic, not the desert, is the driest area in the world.

Extremes of absolute humidity have been measured from about 50 gms/cu. meter, in hot coastal areas near the equator, to less than .001 gms/cubic meter in polar regions. Standards have been proposed as average values for various conditions and we have chosen the following:

Temperate Area	11.5 gms/meter^3
Tropical	27.5 gms/meter^3
Polar	.02 gms/meter^3
Desert	4.4 gms/meter^3

As there is a daily and seasonal variation with temperature on all areas of the earth's surface so there are daily and seasonal variations in humidity.

Available literature does not clearly state the variations in absolute and relative humidity which occur daily and yearly. A 40% change in relative humidity in tropical areas is not uncommon and 20% is reasonable for some temperate areas.

Where the amount of water vapour present is near the maximum value that the air can hold at that temperature, small decreases in temperature cause condensation. This is most common in temperate and tropical areas.

The amount of water vapour in the air decreases rapidly with altitude and above 10 Km is extremely small. Fig. 12 shows measurements made to 30 Km in a temperature zone. You will see that the absolute humidity has dropped from about 11 gms/m^3 at sea level to .1 at 7 Km. In these measurements no value exceeded .04 gms/m^3 up to 30 Km and was about .0025 gms at 30 Km. It has been stated that the absolute humidity remains constant at about .002 gms/m^3 above the tropopause (20 Km).

On this graph are shown the mean values previously mentioned. The dotted lines represent a guess at the distribution of water vapour with altitude above these various areas all reducing to about .001 gms at about 10 Km.

Comparison with the temperature curve will show possibilities of saturation and in fact two positions were measured where the relative humidity reached 100%. These were at 12.7 and 16.3 Km.

The corresponding curve of relative humidity is shown. The relative humidity is below 4% between 20 and 30 Km.

With the higher temperatures around 50 Km and above 100 Km it might be assumed that higher values of Absolute humidity might exist. These areas are,however,far removed from water sources and the temperature inversion layers, through which vapours rise from the surface would tend to cause condensation and dry out uprising air.

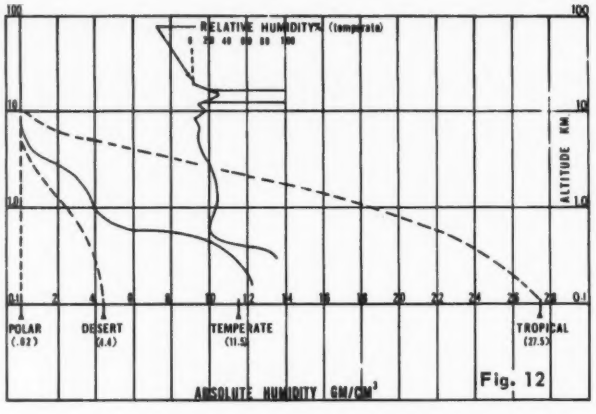


Fig. 12

There is water vapour present however up to 100 Km or more and this vapour is small though it is important, along with carbon dioxide, in re–radiating energy in the infra–red region thus affecting the heat balance and temtures in the upper atmosphere.

Water vapour in the extreme reaches may be due to dissociation and recombination with hydrogen molecules.

Water Vapour concentrations and distribution is related of course to rain and other solid water forms in the atmosphere. It is an influential factor in temperature variation with altitude. It is a factor directly and indirectly in the amount of visible solar radiation reaching the earth and has a dispersive and absorption effect on other electromagnetic radiation.

(References 3, 10, 12, 26, 35).

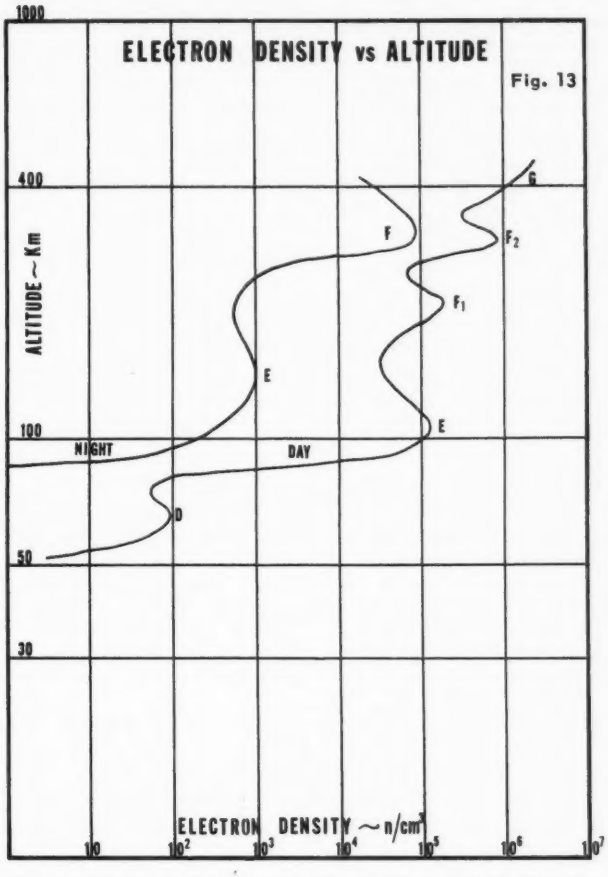
C.4 IONIZED LAYERS

The molecules of the constituents of the atmosphere are affected by components of the sun's radiation spectrum. The most noticeable effects are those due to the components of shorter wavelengths, i.e. those of less than 3000 A. This includes the ultra-violet content and the X-rays.

The molecules and atoms of the atmosphere become ionized by losing one or two electrons but in exceptional cases they can lose all their electrons. Atoms can also take up electrons and become negative ions.

The most important effect of this ionization lies in the distribution of the electrons which give rise to the will known ionized layers. These layers for reference purposes have been given names, i.e. D, E, F_1, F_2 and G layers and are illustrated in Fig. 13.

The concentrations of electrons of various heights that are shown are representative only. The process of ionization under the influence of streams of ultra violet energy is partially offset by the recombination of the electrons with ionized molecules and atoms so that the net result is an equilibrium effect between these two opposing phenomena. Variations in the level of solar radiation will of course effect the equilibrium concentrations so that large variations can be expected with the seasons, geographical location and time of day. In fact the D layer disappears at night in the absence of



direct solar radiation, all the ionized particles having recombined with out the formation of new ionized particles.

The particular regions of the solar spectrum which are believed to cause the ionization at various altitude are

D layer	Radiation at 1216A
E layer	Radiation in the region 10A to 100A
F_1 layer	Cause in obscure
F_2 layer	Radiation in the regions 200A, 304A and 584A

The so called layers are not actual layers of ionized particles but rather regions where the gradient of virtual height against electron density becomes steep.

In addition to the easily recognized layers further cloud - like accumulations of ionized molecules exist called Sporadic E. These occur at heights around 110 Km.

These are believed to be formed by the passage of meteors.

The most well known effect of these layers is the selective reflection of radio waves giving rise to the conception of the critical frequencies for propagation. The relationship between the critical frequency and electron density is

$n = 1.24 \times 10^4 f^2$ where "n" is the electron density per cubic cm. and f is the critical frequency in megacycles

(Reference 1,6, 37)

C5.1 - WIND

Much has been published on winds on a statistical basis and as they are influenced so greatly by local conditions a complete picture cannot be attempted here.

The basic mechanism of the winds at altitudes below 80 Km lies in the convection currents caused by the rise of warm air in the equatorial regions, the resulting flow of cold air from the polar regions and the effect of the Earth's rotation on this process. The earth's rotation causes air masses to move at right angles to the pressure gradient. Thus the replacing of air at the equator does not take place by a simple wind from the poles but rather by a slow moving mass of air, with its associated turbulences that cause the local weather conditions.

In general the wind speed can be assumed to vary as the square root of the logarithm of altitude. Wind velocities up to 500 m.p.h. have been recorded at ground level at the centre of tornadoes and upward winds of 300-450 mph have also been noted.

The pressure exerted by a wind is proportional to the square of the speed.

Between altitudes of 80 and 300 Km there occur drifts of irregularities which are of the nature of winds. These drifts have velocities up to 205 mph and are affected by solar storms which increase the velocities.

Little information of significance has been published on the winds above 300 Km and these remain as an unknown factor.

(References 1, 10, 16, 26, 37)

C5.2 - ACOUSTIC NOISE

The relationship between the pressure produced and the amplitude of the displacing element are readily calculable at ground level and low altitudes and have been the subject of much study recently as an environmental condition. The speed of sound in air is derived from the expression

$$\text{Speed (C)} = \frac{VRT}{W}$$

where v = ratio of specific heats
r = gas constant
t = absolute temp.
w = Molecular weight

This relationship holds good when the variations of temperature, pressure and molecular weight are taken into consideration, up to altitudes of about 120 Km. Above this point the neon free paths of the molecules of the atmosphere become comparable with the wavelength of sound and the velocity of propagation now has little meaning.

It is difficult to visualize the effect of these conditions on the pressure wave from a source of sound,

such as an exploding meteor. Meteors exploding above altitudes of 50 Km are not heard at the surface of the earth and the magnitude of the pressure waves is correspondingly unkown.
(Reference 9)

D- FIELDS, RADIANT ENERGY AND PARTICLES

D.1 GRAVITY

Gravity is an often overlooked environment. The theories behind the cause and effect of gravity do not belong in this paper. Of general interest is the variation of the force of gravity with altitudes.

At the altitudes we are considering this variation may become appreciable and Fig. 14 shows the variation in acceleration due to gravity up to 1000 Km from the earth's surface. This curve is based on figures for the earth's radius and acceleration due to gravity which are shown on the graph.

It is self evident that gravity is a controlling factor in all the environments we have discussed to date.

There are methods of simulating for short periods conditions of reduced or zero gravity.

Local variations depend on the nature and density of the earth's crust at the point of measurement. There are minute daily and seasonal variations dependent on the relative positions of the sun and moon.
(Reference - 6, 39)

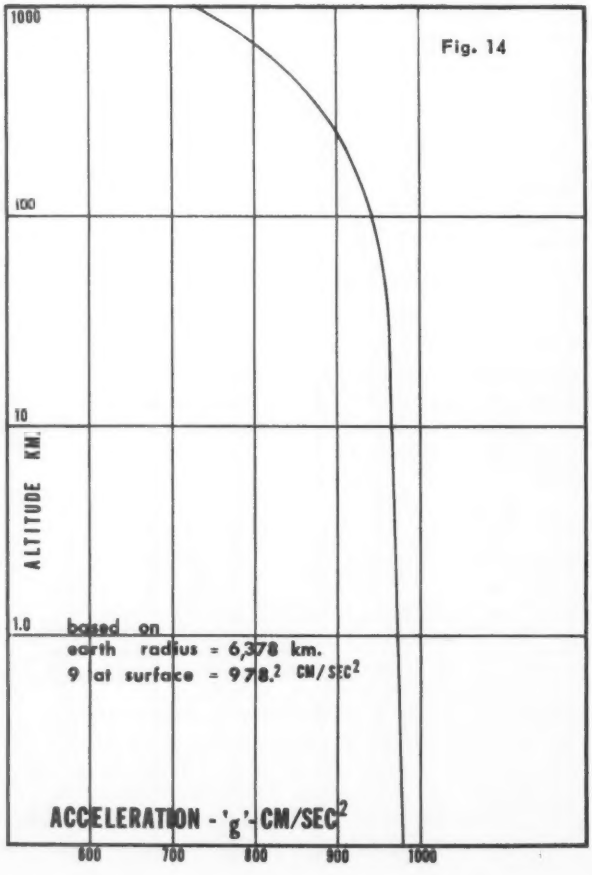


Fig. 14

D.2 MAGNETIC FIELDS

Like most solid magnets, the main portion of the earths magnetic field is within the earth itself. The seasonal fluctuations of this field, however, originate in the electronic current systems which flow in the atmosphere.

The currents are located in the ionic portion of the atmosphere.

The area where the E and F and G layers exist - 70 to 450 Km. Because these layers are ionized they are capable of conducting electricity. These fields are most intense over the polar areas. The interaction of the field produced by these currents and the regular earths field produces innumerable variations in magnetic measurements.

It is also known that at a distance of 35,000 Km from the earth is another such layer producing a flow of electricity which surrounds the earth. This is assumed to be strongest during auroral displays and produces changes in the earth's field. The changes in the earths field are related to the aurora, the ionized layers, changes in cosmic ray intensity and weather patterns including rainstorms and high pressure areas.
(Reference - 6)

D.3 ELECTROSTATIC FIELDS

Atmospheric gas is ionized by radioactivity from the earth, radio active substances in the air and cosmic rays. A pair of ions occurs when these forces remove an electron from a gas molecule. The remaining part of the molecule and the electron become attached to neutral molecules and form a pair of small ions. Condensation nuclei may capture a small ion and form large ions. About 2/3 of condensation nuclei are charged, about 50/50 positive and negative. The ions make the air conducting and also constitute a space charge.

The total charge in the earth in addition to local charges caused by clouds, rain, dust and wind causes a potential difference with altitude near the surface of the earth.

This potential increases at the rate of about 100 volts per meter with respect to the earth's surface in good weather. This will vary with time as the amount of atmospheric pollution and winds vary. Over the oceans where pollution is small, the variation is small, about plus or minus 10 - 15%. Mean values at different locations on the earth vary from 30 to 240. The rate of increase of potential decreases rapidly with altitude.

At 5 Km it is about 1/10 of the surface value, at 10 Km about 1/50th. This is characteristic of decrease in potential with distance from a charged object.

Figure 17 indicates the change of potential with altitude.

During weather disturbances, wild local charges occur 5,000 to 10,000 volts/meter may occur in continuous rain. 10,000 volts/meter in snow storms and up to 50,000 volts/meter in thunderstorms. The field may charge from positive to negative and back for small periods.

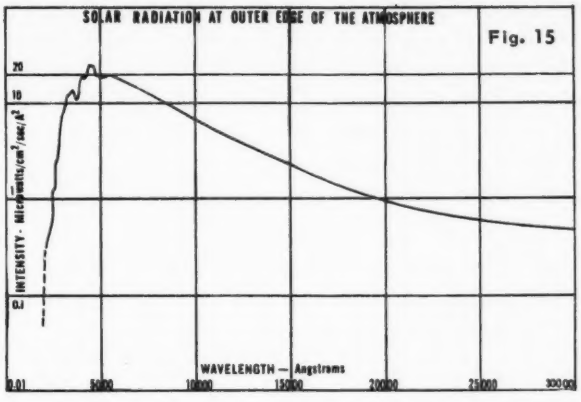
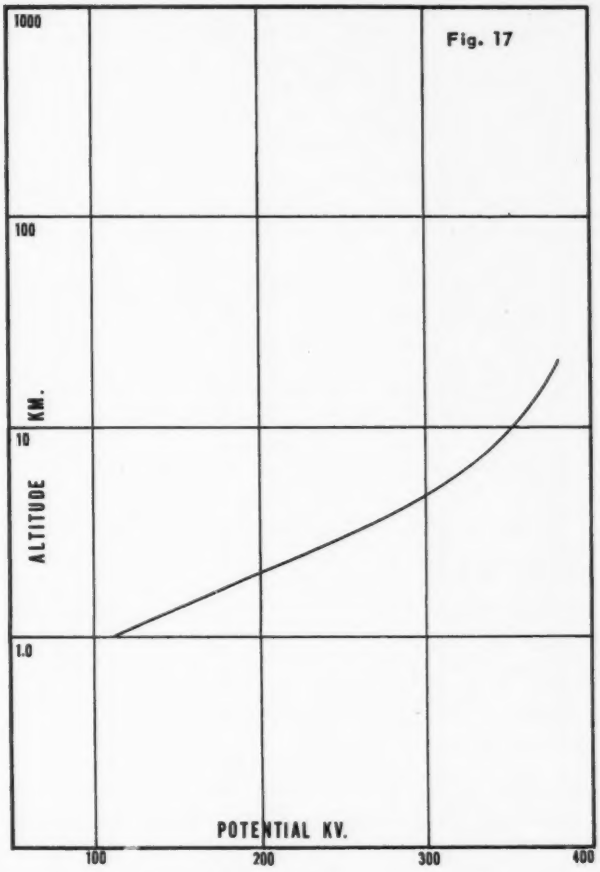


Fig. 16

VARIATIONS OF SOLAR ENERGY AT EARTH'S SURFACE

Latitude	21 March	21 June	23 Sept.	21 Dec.
80°N	155*	1060	153	0
60°	447	979	442	50
40°	486	991	677	318
20°	841	935	832	605
0	896	790	885	843
20°S	841	567	832	999
40°	686	297	677	1060
60°	447	47	442	1046
80°	155	0	153	1136

* Values quoted in calories/square centimetre/day.



About 30,000 volts per meter, discharge in the form of corona or lightning may take place.

Lightning involves current flows as high as 300,000 amperes but in an average about 15,000 amperes. Current peaks last 20 to 1000 microseconds. The release of energy causes local radio interference or noise and "whistlers" or wide range interference.
(References - 26, 34, 40)

D.4 ELECTROMAGNETIC FIELDS

D.4.1 GENERAL

The complete spectrum of electromagnetic waves from audible frequencies through to extremely high frequencies and beyond this to infra-red, light, ultra-violet, X-Ray and gamma radiation has been well defined.

The atmosphere is penetrated by a tremendous number of waves of energy originating from the earth and from space.

Excluding man-made sources the sun is the principal source of natural electromagnetic radiation producing nearly all frequencies various visible effects.

Other bodies far distant in space are a source of continuous radiation in the frequency ranges we use for communication as well as in the visible light range.

Unwanted transient bursts of energy, or noise, also have earth and space origins.

D.4.2 SOLAR RADIATION

The sun is the direct source of most of the environments which concern us. Most of these environments arise in one way or another from solar radiation. The energy spectrum of the radiation has been established as being composed of all wavelengths down to at least 7A and possible beyond.

The total energy arriving on a plane surface, normal to the sun, at the edge of the Earth's atmosphere is practically constant at 1.94 calories per square centimeter per minute when the earth is at it's mean distance from the sun. Variations of 1 to 2% have been recorded and the spectrum below 30000A is shown in Fig. 15.

For other surface, not normal to the sun, and at distances other than the mean, the intensity Io is given by

$$Io = 1.94\ (osZ)\ \left(\frac{r_o}{r}\right)^2 \text{ calories per sq. cm. per minute.}$$

where Z is the Solar Zenith distance angle from the Earth.

and $\left(\frac{r_o}{r}\right)$ is the ratio of the earth's mean distance from the sun to the actual distance from the sun.

Of this total energy only 40% reaches the earth and this energy does not have the same spectral distribution.

Selective absorption of the solar energy takes place in it's passage through the atmosphere resulting in the conception that the atmosphere has two "windows", an "optical window" and a "radio window". The former allows transmission in the band 2,900A° to 30,000A°, the latter, 1 cm. to 45 meters.

In addition to the radiation energy the sun emits particles, consisting of electrons, protons and stripped nuclei of atoms. None of these particles reaches sea level but their effects will be discussed later.

Even without the intervention of clouds, the radiation suffers depletion due to:

1. Scattering.
2. Absorption by Water Vapour.
3. Absorption by Solid Particles (Dust and Water).
4. Scattering by Air Molecules.
5. Absorption by permanent gases.

The extinction of the radiation will depend upon the path length through the atmosphere and hence the zenith angle. The rate of extinction is a function of the wavelength, shorter wavelengths being more rapidly absorbed or scattered. Molecular scattering is inversely proportional to the 4th. power of the wavelength. The net result is that the shorter wavelengths never reach the earth's surface in sufficient quantities to present a serious biological hazard.

The total solar radiation although constant for the most part fluctuates with the occurrence of sun spots. These sun spots cause temporary increases in radiated energy mostly in the region 10A to 800A where the energy levels may be enhanced by a factor of 2 or 3. Intense radiation takes place as a wavelength of 1275.7A during these periods of activity and these produce the disastrous effects on communications that are so well known. In the region 3000A to 10000A the increase in energy level is less than 1%.

The total energy reaching the earth's surface on a typical desert day is 105 watts/sq. ft. (1.6 calories/minute/sq.cm.) and has an approximate composition of 57% Infra Red, 44.5% Visible Light, 4.5% Ultra Violet.

The variations of the total energy received at the surface of the earth are shown in Fig. 16.

As we have shown earlier this radiation is the factor which determines temperatures, humidity, ionized layers and other conditions. No environment is independent of solar radiation.
(References 6, 10, 11, 21, 26, 37).

D.4.3 AURORAE

In certain regions of the sky, centred about 23° from the geomagnetic poles, brilliant formations of light of characteristic patterns appear. These are the aurorae and occur at heights between 65 and 1100 Km, but mostly at a height of 100 Km.

The exact mechanism of formation has not yet been established but it is certain that they are caused by charged particles emanating from the sun, probably protons. These particles cause ionisation and dissociation of the atmospheric molecules and this excitation is accompanied by the emission of energy which appears as light.

These particles have energy levels greater than 10^6ev but the average energy is only one thousandth of that of the slowest cosmic particles.

The various forms that the displays take are attributed to the interaction of the earth's magnetic field with the high speed particles. This interaction also produces a focussing effect leading to the two distinct zones of occurrence.

The aurorae represent areas of high concentration of electrons and hence have a disruptive effect on radio communications.
(References 37, 6).

D.4.4 AIR GLOW

In the absence of moonlight or sunlight some light falls on the earth comprising zodiocal, galactical, starlight and air glow.

This air glow, which contributes two fifths of the light from the night sky, originates in the earth's atmosphere and is caused by the recombination of ionized atoms and molecules mostly oxygen and nitrogen. The altitude of origin of this light has not yet been established.

During daylight the air glow intensity is some 10,000 times stronger than at night. The intensity decreases rapidly, almost exponentially from sea level up to 35 Km and is then constant at about 3% of the sea level value.

This daytime air glow is of course masked by the sunlight and is actually caused by the excitation of molecules of the atmosphere to a state of resonance. This resonance accounts for the difference in the spectrum for daytime and nightime air glow.
(References 37, 6).

D.4.5 NOISE

Man-made causes of noise are beyond listing. Natural sources are largely from the sun and local weather conditions.

Lightening produces in addition to a heavy local disturbance, a long distance phenomena known as "whistlers" in the low frequency bands.
(Reference 40).

D5 NUCLEAR PARTICLES

In addition to the energy radiated by the sun the earth's atmosphere is being constantly bombarded by charged particles, consisting, in the main, of stripped nuclei of atoms. These particles, the primaries, have estimated energies in the range 10^9 to 10^{17}ev, which is far in excess of the fastest particles produced in any laboratory. These particles enter the atmosphere but never penetrate to within 24 Km of the earth's surface as they suffer collisions with molecule of the atmosphere and produce secondary particles, such as mesons, neutrons, photons, electrons and positrons, some of which arrive at the earth's surface. However, between 55 Km and 160 Km the flux is known to be constant.

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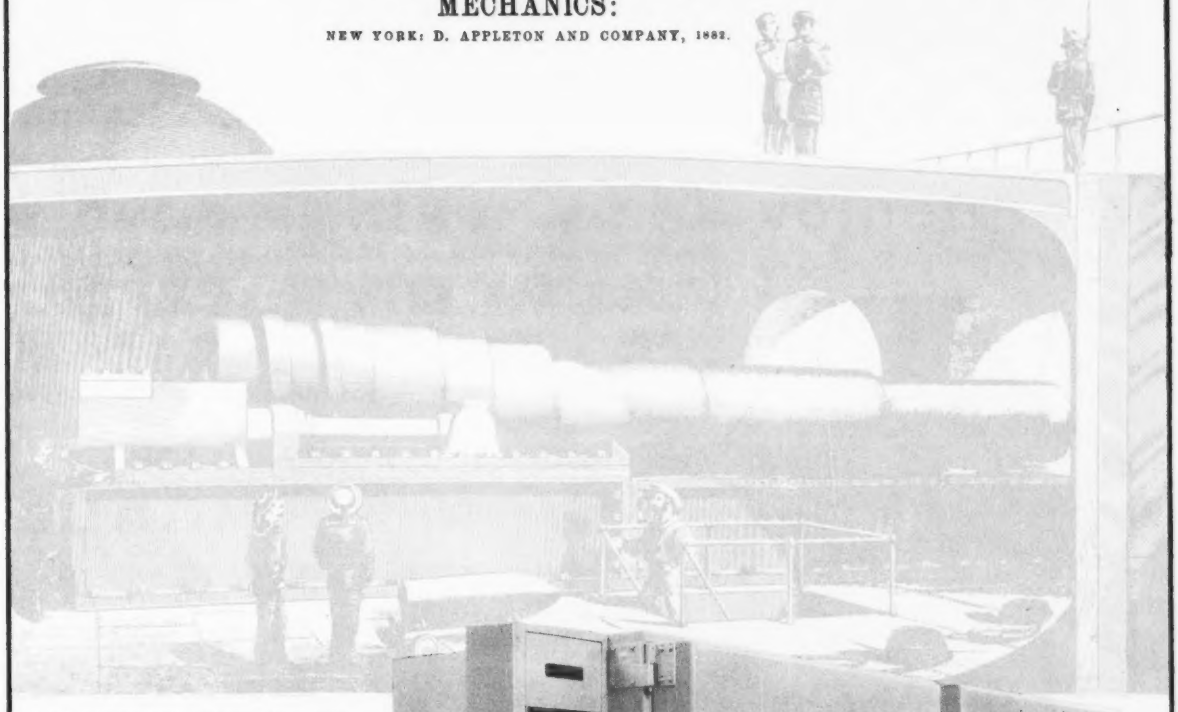

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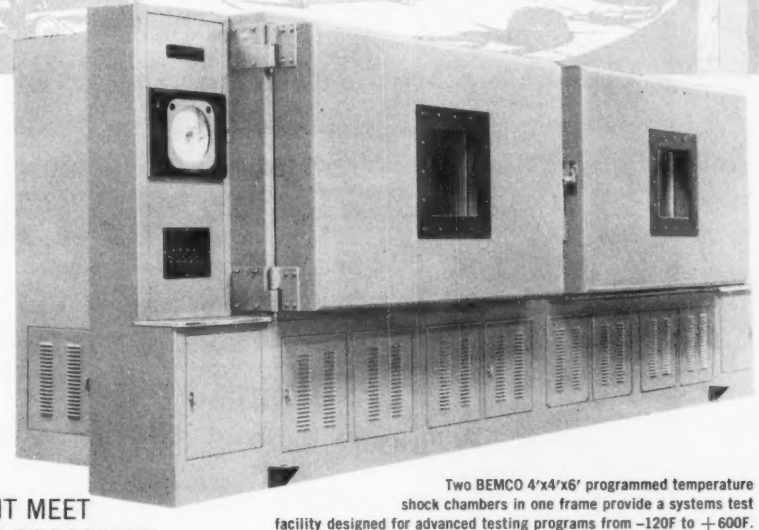

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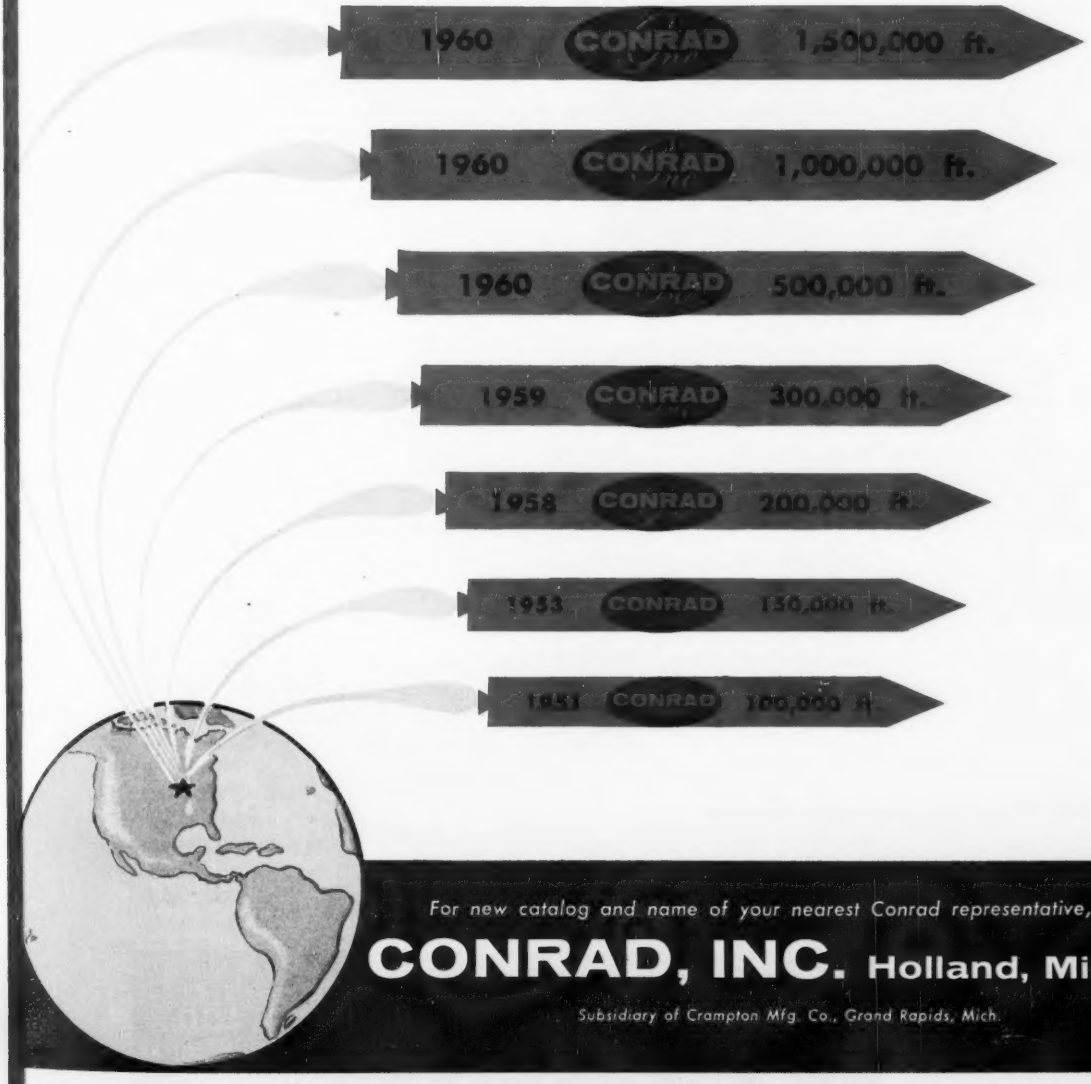

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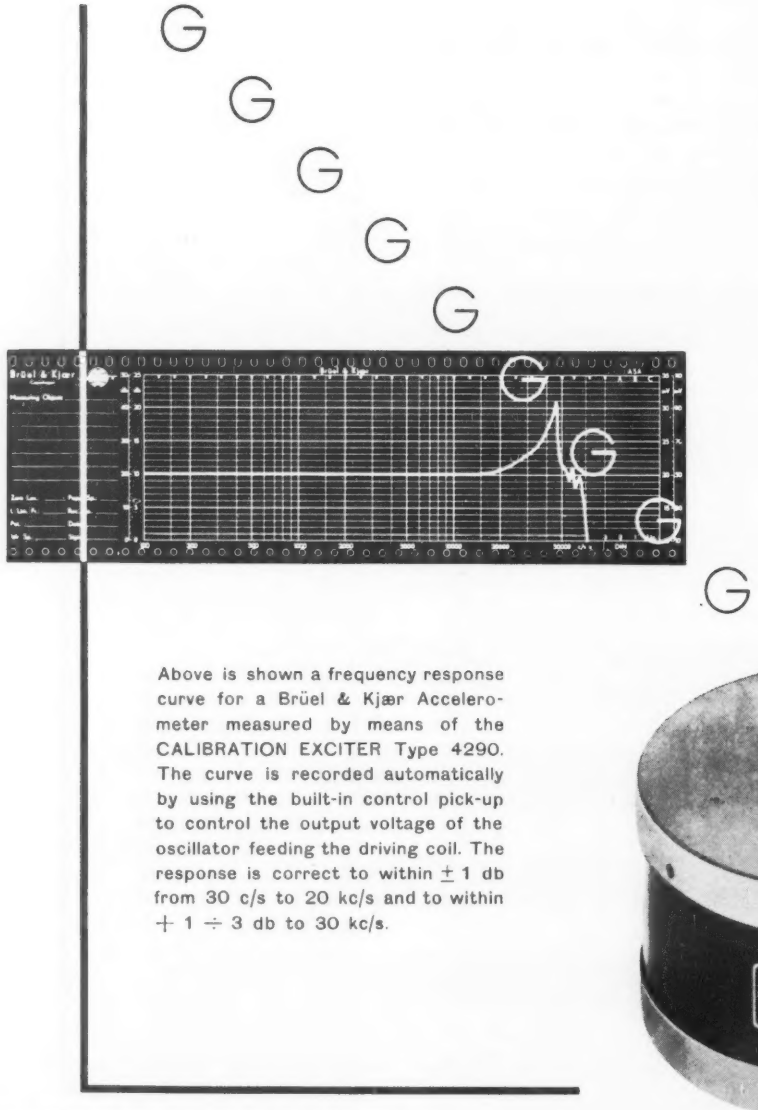

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The total flux of these particles amount to 4.6 particles per minute per square centimetre per steradian (from a vertical direction) and the average over the hemisphere is 7.5 particles per minute per square centimetre per steradian. The flux is dependant on latitude due to the focussing effect of the earth's magnetic field but no latitude effect is observed above 50° to 60°. The flux at the equator are 1/3 of the values quoted and at the poles three times the values.

The presence of stripped nuclei of all elements of the periodic table up to iron have been detected in the streams and the distribution of particles is approximately 83% protons, 15.7% helium nuclei (alpha particles) and 1.3% nuclei of atoms heavier than helium.

As an indication of the magnitude of this environment, the primaries are known to be capable of penetrating up to 15 cms of lead and the secondary particles which comprise the greatest biological hazard, travel in all directions and can be encountered at all altitudes.

Of lesser energy and importance from an environmental standpoint are the nuclear particles which are constantly emitted from the earth itself. These have been emitted by the elements of the earth since its formation but some have been absorbed from the atmosphere by plants from radioactive carbon dioxide.

The latest source of particles which has received considerable advertisement since the war lies in man-made atomic reactions. The present magnitudes involved are not published but these will probably increase in the future.
(Reference 37)

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BIOLOGICAL EFFECTS OF HIGH INTENSITY NOISE

by WILLIAM P. BAGLEY, B. AERO. E, M. Sc.

(Concluded from the June Issue)

Definite evidence exists that persons who must perform duties in a zone of high intensity noise must put extra effort into their work to maintain a certain level of accomplishment. They tire more readily and at the end of the day feel much more fatigued than normally. The efficiency of persons working under these conditions can be greatly reduced depending on the type of work being done. Steady continuous noise such as the drone of the engine and propeller of an aircraft on a long flight produces drowsiness. This suggests the idea that mental and physical fatigue do occur. Irregular noises such as un-synchronized propellers and radio static produce irritability as well as fatigue. Naturally, the effect of aircraft noise on the pilot varies with the intensity and frequency of the noise. However, there is no question that as the noise becomes louder real stress, both physiological and psychological, is experienced by the subject.

High sound pressure levels also affect various systems of the human body (Figure 6). Noise levels greater than 60 db inhibit normal muscular activity of the stomach and intestines, reduce the flow of saliva 44%, and decrease the normal flow of gastric juices. Levels from 80 to 90 db decrease gastric contractions 37%. This inhibition of gastric activity may be a factor in the gastric disturbances which appear frequently in aviator's and bears the name of "aviator's stomach" (1).

EXTRA-AUDITORY EFFECTS

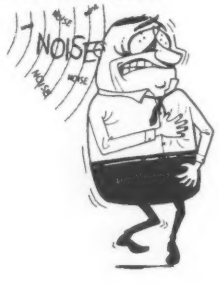


Figure 6

In the range from 130 db to 140 db more pronounced and discomforting effects appear. Soft tissue of the body, especially in the nose and throat may vibrate. There may be pain similar to a dull toothache or a sensation that the enamel is being torn off the teeth. Several claims have been made that tooth fillings have been loosened. The chest, abdominal cavities, and skull undergo a feeling of pressure and a state of depression may exist.

At sound pressure levels exceeding 140 db, the body cavities, bones and muscles of the arms and legs may vibrate if low frequencies are present. There may be a fatigue, inability to concentrate on mental problems and weakness in the knees. Vision may be blurred, possibly because of vibration of the eyeballs, but recovery of normal vision is rapid and complete after cessation of noise. Some individuals experience a feeling of intense awe or fear. This fear reaction probably dates back to days when the detection of even a faint sound coming from a potential source of danger might mean the difference between life and death.

Exposure to these high sound pressure levels also causes earache, headache, weariness and irritability. Severe pain in the ears and dizziness leading to vomiting may result. There may even be interference with touch under such circumstances. A drop in rate of respiration and blood pressure due to nervous reflex activity may occur. At sound pressure levels greater than 160 db, the eardrum may be ruptured.

Interference with communication is another very important aspect of noise. In many cases such as receiving important instructions via radio in aircraft, noise in the speech frequency range, 200 to 4000 cps, may not only be annoying and disconcerting, but may mask out certain portions of the message. Masking is the inability to hear sounds of the same frequency and intensity as the interfering noise. However, individuals exposed to this type of interference for lengths of time show a certain degree of "recruitment" or the ability to read the message more clearly.

At sound intensity levels of white noise generated by modern military jet aircraft, a considerable amount of noise reaches the inner ear by bone conduction. The intensity of the sound is so great the whole skull vibrates and these vibrations are transmitted to the inner ear. As long as the channels of the outer ear are open, bone conduction does not add to the total loudness preceived by the inner ear. However, if the channels are plugged, bone conduction places a definite limit, about 20 to 30 db, on the attenuation provided by ear protection.

TYPES OF EAR PROTECTIVE DEVICES

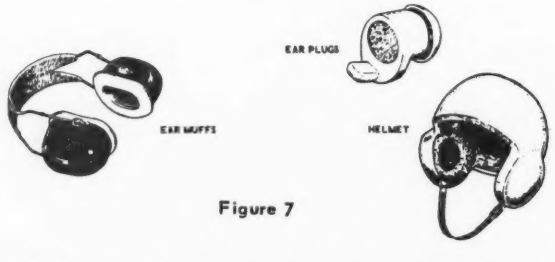


Figure 7

Skull absorption of sound energy depends upon the amount of unprotected head area exposed to high intensity sound. Helmets designed to attenuate sound afford considerable protection, but at high sound pressure levels the long bones of the body vibrate and a certain amount of sound energy is transmitted to the skull through these bones.

Whether or not hearing loss occurs due to vibration of the skull exposed to the sound field of jet aircraft is not known. Yet, experiments with animals indicate that hearing is more affected by vibrations transmitted through the bones than by sound waves transmitted through the ear. In one experiment a group of guinea pigs was exposed to the sound of an electric bell suspended in the cage. Another group was subjected to the vibrations coming through the floor. After 60 days exposure there was no evident damage in the first group. However, in the group experiencing sound conduction through the floor, the animals became emaciated and after 14 days two died. Others showed signs of degeneration of the cochlea (1).

In another experiment mice were placed in a cage on the floor and another group suspended by a coil spring from the beams in a factory where steel bars were being hammered. After 8 months the group suspended by the spring showed no damage to auditory apparatus. Damage was extensive in the group placed on the floor, basilar membranes, organs of Corti, and ganglion cells and fibers showed signs of deterioration (1).

Rodents and guinea pigs exposed to sound levels of from 144 db to 157 db absorbed enough sound energy to raise their temperature 10 to 15 C. causing death in ten minutes. Calculations indicated about 3 db is the difference between death and indefinite survival (2). In man, if the hands are held with the fingers close together in a high sound pressure field, the skin between the fingers definitely undergoes an increase in temperature. However, the energy absorption of human skin at these frequencies is less than one-thousandth of the total energy.

The majority of these experiments indicates that skin heating and sound conducted through the bones have a definite effect on animals, yet further work is necessary before definite conclusions can be drawn as to the effect on human beings.

The foregoing effects are the results of exposure to high noise levels in the audible frequency range, normally from 20 to 20,000 cycles per second. Higher, or ultrasonic frequencies of present day jet engines are not considered intense enough to produce harmful effects on human beings. They are quickly attenuated by air and ear protective devices prove to be an effective countermeasure.

Since the earliest days of man's exposure to high intensity noise many substances have been used to plug the ears as protection from loud noises (Fig. 7). Cotton, mixtures of cotton and wax, potters clay and rubber ear plugs are some of the materials tried. Plain cotton reduces the noise by about 3 db (one half) and rubber ear plugs, or cotton and wax about 25 to 30 db. This type of ear plug, which blocks the conduction of sound by air, is more effective at higher frequencies than at lower frequencies. At sound pressure levels of over 85 db attenuation of low frequencies is reduced, allowing a considerable amount of noise to reach the inner ear through bone conduction. One other disadvantage is that objects worn inserted in the ear canal are uncomfortable and few persons care to tolerate them for long periods of time.

Ear defenders or ear muffs have in general the same attenuation characteristics as ear plugs, however, they are more easily donned and removed and are much more comfortable. They are usually constructed with a hard shell on the outside and sponge like material lining the inside to provide further sound attenuation. A liquid filled seal fits the ear defender snugly to the head and prevents leaks through which sound may be conducted to the inner ear. One of the most effective means of ear protection is simply blocking the ears with the palms of the hands as this gives more shielding than most ear defenders.

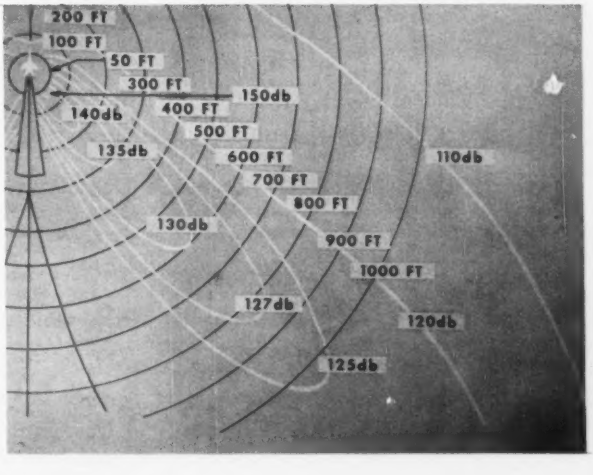
Another method of sound attenuation is the use of a hard helmet, similar to that worn by pilots, with headsets or ear defenders inside. This method provides some protection from sound conduction through the skull as well as from airborne noise. No matter what device is used for protection, it must fit tightly because any small air leaks will allow considerable noise to be transmitted to the inner ear.

The most efficient present day ear protective devices attenuate sound no more than 40 db. Sound levels in present day aircraft cockpits have reached 120 db (Fig. 8). Sound levels near the aircraft with afterburner going reach 167 db., and future aircraft with more powerful engines will raise this noise level.

A word about human tolerances to high levels of noise. Levels above 100 db are definitely considered not to be safe. Levels below 90 db are considered safe for short repeated exposures (6). Figure 9 recommends maximum limits for various sound pressure levels.

From these data it is evident that even with the proper use of the most efficient sound protection equipment it is possible to expose personnel to injurious noise levels especially in the case of individuals operating or servicing modern jet aircraft. Research in more efficient ear protection is mandatory. More research is essential to stay abreast of increased sound attenuation problems which will be associated with future systems of greater power.

Figure 8



HUMAN EXPOSURE LIMITS TO VARIOUS SOUND PRESSURE LEVELS

Figure 9

db LEVEL	NO PROTECTION	EAR MUFFS
100	4 hours	
110	1 hour	
120	5 minutes	4 hours
130	0	1 hour
140	0	5 minutes
150	0	0

CONCLUSIONS

Loud noise has detrimental effects on human beings. Problems associated with exposure of personnel to high intensity noise will increase with the development of more powerful aircraft engines. Partial or complete hearing loss, physical trauma, and decrease in efficiency are the costs of exposure to high sound levels. These costs are directly related to the frequency, sound pressure levels and exposure times.

Ear protective devices are inadequate. Ground personnel and flight personnel are subjected to sound pressures which exceed safe levels in and near the aircraft. This condition exists even while wearing the most efficient current ear protection. The cumulative effects of this excessive noise can possibly jeopardize the successful completion of a mission.

No specific treatment for deafness due to exposure to aircraft noise exists. The only method of combat is to prevent injury to the organs of hearing. During exposure to any noise levels exceeding 90 db ear protection should be mandatory. The exposure time to high sound pressure levels should be kept to an absolute minimum consistent with safety.

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NOTES FROM THE EDITOR

CHARLES W. DANIELSON
TECHNICAL EDITOR

Readers of the Journal have probably noticed the change in format which occurred in the June issue. We will still have the symbolic covers representative of the theme in each issue and continue printing on non-glare paper. Otherwise, significant changes have been made in order to constantly strive to improve the Journal for its readers.

Several of the miscellaneous categories have been deleted in order to have more space for the technical articles. Our advertisers are now located in the front, back and center section of each issue as in other technical publications. This permits us to run the articles completely on opposing pages without interuption of continuity.

The technical articles and other sections are now set in two columns on each page, reducing eye motion and increasing continuity. The wider columns are more practical from a publishing standpoint for the reducing and insertion of graphs, charts and photographs in the body of the article.

As a result of the increased space available, we hope to be able to present four complete articles in each issue. Articles will only be continued in the next issues if they are exceptionally long.

In this issue the article "A Synopsis of Natural Environments to Heights of 1000Km." by A. P. Harris and E. W. Parrott is concluded. Almost all known environmental conditions on the earth's surface and to a nominal altitude are briefly discussed. The Journal would like to publish more articles elaborating on these many environments, particularly any change in the parameters or in means of simulating them.

If you are presently writing or intend writing an article, please contact me. The address is 11916 West Washington Blvd. Los Angeles 66, California. We would appreciate reviewing your article for possible publication in the Journal.

I.E.S. NEWS LETTER

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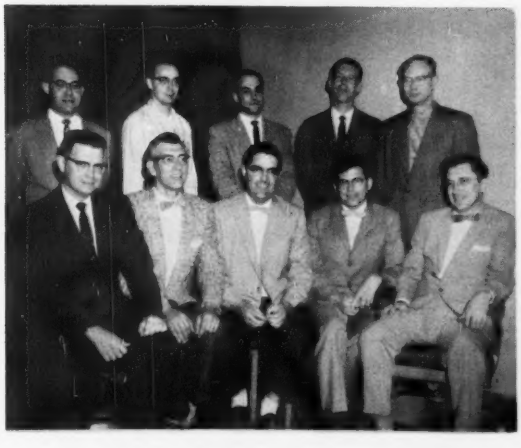


The IES has just elected the above officers to carry out its program for the 1960 season. During the next twelve months you can expect something new and different in these technical meetings. Plans are being made to bring experts from all over the country to share their experience and knowhow with the leading design engineers and test engineers in the Chicago area.

As man probes further into space, the demand on the design engineer is increasing rapidly. The IES therefore is expanding and improving so that it may make a greater contribution to the present and future needs of of the industry.

The 1960 officers of the Greater Chicago Area Chapter of the Institute of Environmental Sciences
Back Row (left to right)
Mr. Robert Jacobson, National Director; Mr. Martin Dorsey, Vice President; Mr. Herbert J. Saunders, Secretary; Mr. Donald J. Fox, President; Mr. Edgar Pauls, Treasurer
Front Row (left to right)
Mr. Kenneth C. Bowman, Vice President, Rockford Section; Mr. Richard Prock, Assistant Program Chairman; Mr. Roland J. West, Publicity Chairman; Mr. Matthew A. Gartner, Membership Chairman; Mr. Theodore Pryst, Program Chairman

The Boston Area Chapter of the Institute of Environmental Sciences has announced the completion of a twelve week lecture series on environmental testing from April 5 to June 28 at Northeastern University, Boston. The lecture series was planned and organized by Gerhard Doerring and Peter Fowler, President and Program Chairman respectively, of the Boston Chapter, in cooperation with Dean Albert Everett and Forest Hallet of Northeastern University.

At a University sponsored banquet on June 28, certificates were awarded to the more than 230 professional persons who attended the weekly lectures, covering all phases of environmental testing. Approximately forty Greater Boston technical organizations were represented.

According to Boston Chapter and Northeastern officials, a similar lecture series will be held next year. The series was the first of several activities scheduled for 1960 by the Boston Chapter.

For additional information, contact Mr. David Hemingway, Manager, Environmental Laboratories Division of Richard D. Brew and Company, Incorporated, 90 Airport Road, Concord, New Hampshire, Telephone - CApitol 5–6605.

MID-ATLANTIC CHAPTER

The Pennsylvania State University, in cooperation with the Mid-Atlantic Chapter of IES, will present a 12-lecture course on Environment and Environmental Engineering at the Board of Education Building Auditorium, Phila., Pa. on Monday nights, 7:30 to 9:30 PM, from 19 Sept to 5 Dec 1960. The course contents and lecturers are shown in the preliminary anouncement.

1– Philosophy of Environmental Testing
Description of the environments. Purpose of environmental testing and types of tests. Testing equipment required to simulate actual and accelerated environments. Simulation of combined environments. Correlation with field conditions. Discussion of Military Specifications for environmental testing procedures. DAVID ASKIN, Chief, Test and Evaluation Branch Frankford Arsenal, Phila., Pa.

2– High and Low Temperature and Humidity Environments
Requirements for high and low temperature and humidity, natural and induced environments, and the various methods of creating such environments in test chambers. Methods of computing heating and cooling systems for test chambers. FRED HERMANN, Development Engineer, Tenney Engineering, Inc. Union, New Jersey

3– Solar Radiation Environments
Solar radiation at sea level and at high altitudes discussed. Solar radiation spectrum analyzed. Methods of measurement reviewed. Methods of simulation discussed. Simulation of solar radiation combined with other environments is described. JOHN GELHARD, Advanced Systems Engineer, General Electric Co. Missile and Space Division, Phila., Pa.

4– Sand, Dust, Fungus and Corrosion Resistance (Salt Spray Test)
Shipping, storing and operation environments. Detailed study of fungus, dust, salt spray and atmospheric contaminants. Accelerated tests to simulate exposure. K. C. COMPTON, Chairman of the A. S. T. M. Advisory Committee on Corrosion, Bell Telephone Laboratories Murray Hill, New Jersey

5– Outer Space Environment
Background, description and magnitude of natural and induced environments in outer space. Anticipated deleterious effects on materials and equipment. Methods of simulation. PETER MARFONE, General Electric Company, Missile and Space Vehicle Division, Phila., Pa.

6– Nuclear Energy Environment, Instrumentation (Application and Facilities
Nature of nuclear particles, measurement of radiation levels, effects of radiation on materials and components, and methods of test. DR. ALAN E. SUROSKY, President, General Testing Laboratories Moonachie, New Jersey

7– Vibration Testing Fundamentals
Why vibration testing? Principles of vibration. Methods of simulation. Guidelines for sinusoidal vibration testing. ROBERT M. JONES, President, Tek-Sel, Inc., Hatboro, Pa.

8– Modifying Environmental Conditions by Use of Shock and Vibration Isolators
Consideration of specific environmental conditions and incorporation of suitable mounting arrangements to reduce the severity of the environment on the equipment. JESSE MARKSON, President, E. R. A. Incorporated, Great Neck, N. Y.

9– Instrumentation for dynamic measurements
Various types of pick-ups employed for sensing dynamic mechanical motions. Principles of operation and limitations in different measurement techniques. Analysis of transient measurement. DR. IRWIN VIGNESS, U. S. Naval Research Laboratory Washington, D. C.

10– Shock Tests and Shock Spectra
Philosophy of shock testing and current types of testing procedures. Methods of simulation of shock. Shock spectra and its correlation with the environment. MAX LAZARUS, Chief of Engineering Proposals and Planning. Barry Controls, Inc., Watertown, Mass.

11– Random Vibration
Comparison of random vibration and sinusoidal vibration testing. Statistical treatment of vibrational environments. Evaluation and interpretation of service measurements. DR. ROBERT M. MAINS, Specialist, Shock and Vibration Knolls Atomic Laboratory, General Electric Company, Schenectady, New York

12– Acoustic Noise Environment
Degradation of equipment performance caused by severe sonic environment. Control of the temporal and spatial aspects of the exciting field. The importance of these aspects in both testing and field behavior. E. J. KIRSHMAN, Manager, PAM Associates, Baltimore, Md.

TECHNICAL INFORMATION

IES PUBLICATIONS FOR SALE:
1959 PROCEEDINGS-

54 papers presented at the 1959 National Meeting of the IES in Chicago, Illinois. Volume is well illustrated and covers earth and space environments, reliability, instrumentation, ground support equipment.

Members $8.00; Non-Members $12.00

1960 PROCEEDINGS

Papers presented at the 1960 National Meeting of the IES in Los Angeles, California. Volume is well illustrated and covers earth and space environments, biology, reliability, space vehicles, instrumentation.

Members $8.00; Non-Members $12.00

1960 REPRINTS

Reprints of each paper presented at the 1960 National Meeting and published in the 1960 Proceedings.

Each Reprint $0.50 each

Any of the above material can be ordered from the National Office address, IES, Box 191, Mt. Prospect, Illinois.

Brief summaries of papers presented at the 1960 National Meeting will be printed in each issue of the *Journal* for those interested in ordering reprints.

The Reaction of the Human Body to Extreme Vibration by R. R. COERMANN & E. B. MAGID; Wright Air Development Division, Air Research & Development Command. USAF.

The reactions of the human body to vibration may be divided into three closely related areas: (1) mechanical, (2) physiological, and (3) psychological. Examples of the several effects of vibration, and criteria for human tolerance to vibration, and buffeting are presented.

Nuclear Environmental Testing by LEONARD B. GARDNER; Electronic Equipments Division, Litton Industries, Inc., Beverly Hills.

The testing of materials for use in a system propelled by atomic energy will be discussed. Particular emphasis will be placed upon the instrumentation used in such tests, its effect upon the nuclear field, and the calibration of the instruments.

The Ability to Apply Forces While Tractionless by E. DZENDOLET, Wright Air Development Division, ARDC.

The torque that a maintenance man can exert within a space vehicle while weightless, and hence tractionless, was analyzed and predictions were made. Certain of the predictions were verified experimentally. Suggestions are advanced regarding optimum body position, handholds, maximum torque limitations, the use of impulses, and the design of hand tools.

Bio-Magnetics by H. S. ALEXANDER; Missile Division, North American Aviation, Inc.

Research on the effects of magnetic fields upon living matter are summarized. Findings are interpreted in terms of greatest probable application to space flight, including: Magnetic phosphenes, ionizing radiation compensation, and increased metabolic efficiency. Other effects such as tissue growth, apparent retardation of aging processes, increased activity, lower body temperature, and male sensitivity, are discussed briefly.

The Effect of Micrometeorites on Reflecting surfaces by R. E. HENDERSON; Allison Division, General Motors Corp., & PAUL STANLEY; Aeronautical Engineering Dept., Purdue University.

A methodical formulation is developed which can make use of all available information on penetration characteristics of high speed particles, as well as frequency and size distribution of micrometeorites. An experiment is suggested which will provide considerable information for use by scientists working in the field.

The Solar Wind as a Hyper-Environmental Parameter by T. A. BERGSTRALH, L. J. KIEFFER & I. H. BLIFFORD; Aeronutronic Division, Ford Motor Company.

Evidence for the presence of a highly ionized gas of solar origin in interplanetary space, is reviewed. Consequences of a large flux of high energy particles is causing erosion of satellite materials, and questions relating to the existence of micro-meteorites and the solar energy balance are discussed. Experimental programs are suggested.

Protection Versus Design for Environmental Resistance by K. N. TINKLEPAUGH & R. A. HARMEN; U.S. Naval Missile Center, Point Mugu.

This paper covers a rational approach to the problem of determining the extent to which environmental protection or ruggedized design should be employed in terms of over-all development effort.

Waste Heat Radiation in a Space Environment by P. E. KUESER; Small Motor Division, Westinghouse Electric Corporation, Lima.

The design of a waste heat radiator is analyzed where radiation heat transfer and a meteoroid environment influence its design for reliability. Parametric curves of a finned tube radiator are given illustrating weight, tube size, fin spacing, temperature and life.

Thermal Environment of Electronic Equipment in Space Vehicles by N. E. WOOD; Santa Monica Division, Douglas Aircraft Company.

This presents a discussion and analysis including tests to determine transient thermal conditions in space vehicle electronics.

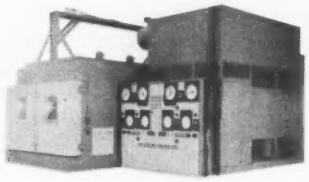
A Space Flight Escape System by WARD BISHOP & ERNEST A. SCHUMACHER; Space Flight Division. The Martin Company, Baltimore, Md. & FRED BLOETSHER, Aero-mechanics R & D Dept., Goodyear Aircraft Corporation.

The feasibility of escape from a glide re-entry vehicle is directly associated with the limits of environment including atmosphere, temperature and acceleration. Design considerations and a proposed solution are presented.

NEW PRODUCTS

NEW CONRAD DUAL CHAMBER

Conrad, Inc. announces a new temperature-shock, temperature-humidity control chamber with numerous exclusive design features. The chamber Model WD—585—50—50—50—50 features independent refrigeration, heating, and humidity systems for the left half and the right half of the chamber. A front to back movable separator partition divides the chamber. The partition is controllable from a power hoist. This permits use of the chamber as one common test space, or with the partition lowered, as two independent chambers.



Another feature is the controllability of each half independently. It is possible to have +500°F. on one half of the chamber and —100°F. on the other half of the chamber. Special accessory carts are available to permit automatically moving a product load from the hot to the cold side or vice versa.

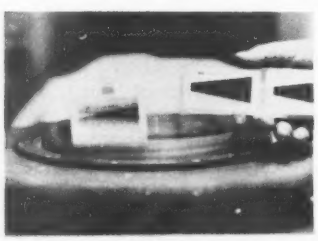
Write to the nearest Conrad field office or to the main plant, care of Sales Application Engineering Department for additional information or quotations.

MB OFFERS 'OPTICAL WEDGE' FOR VIBRATION TEST MEASUREMENT

NEW HAVEN, Conn. — A simplified method for measuring displacement in vibration testing is available without charge from MB Electronics, a Division of Textron Electronics, Inc.

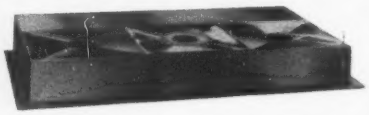
The "optical wedge" is a pressure-sensitive wedge-shaped sticker that can be affixed to a flat surface on the object under test. The long axis of the wedge should be exactly perpendicular to the axis of vibration. Then, as the wedge vibrates with the piece under test, two triangles will appear. Displacement is indicated on the scale directly below the point of the darkest triangle.

These wedges are available in limited quantity and without charge from MB national sales representatives, or by writing J. C. Stephens, MB Electronics, 781 Whalley Ave., New Haven 8, Conn.



NEW HARRIS 3-ZONE MASS PRODUCTION LIQUID BATHS FOR PRECISION TEMPERATURE CALIBRATION PROVIDE EXTENSIVE TEMPERATURE RANGE FROM +150° TO -85° C.

For precision temperature calibration at a rapid production rate and in large quantities, a new unit by Harris Refrigeration Co., Cambridge, Mass., provides three separate agitated liquid baths. The hot bath has a temperature range of +150° to +50° C. with capacity of 6,000 BTU per hour. The medium bath provides a range of +50° C. to +20° C. with capacity of 1,000 BTU per hour, while the cold bath is -20° to -85° C., capacity of 6,000 BTU per hour.



The unit delivers complete recovery in only 4 minutes with 1,000 BTU thermal load. Temperature variation in each bath is less than 1° C. while point control is ±1° C. (repeatability, speed of response, and on-off differential). Each chamber has a capacity of 5 cu. ft.

The cabinet is stainless steel with tops contoured at the rear to drain off oil drippings from fixtures hung on the drying racks. Open rolled edges on the top wall prevent liquids from creeping beyond the top.

Further data may be secured by writing Harris Refrigeration Co., 308 River St., Cambridge 39, Mass.

NEW HIGH TEMPERATURE (100 TO 1000° F) INDICATING TEMPERATURE CONTROL

A new, compact, remote bulb, high temperature indicating temperature control, type E36N, is now being offered by United Electric Controls Company, Watertown, Mass. Ideally suited for ovens, test equipment, plant processes, laboratories and other industrial heating applications, it combines accuracy and sensitivity over wide ranges (100 to 1000° F).

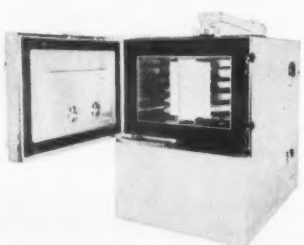
Easy reference between the setting and controlling temperatures is provided by a single scale with two pointers. The unit may be readily set to control and indicate anywhere within scale limits and calibration is easily checked.

Several switch actions are available including normally closed, normally open and double throw. Ratings are 15 or 20 amp 115/230 Volts AC. All snap-action switches are single pole and suitable for up to 180° F ambient temperatures.

For complete specifications and price information on the E36N and other indicating temperature controls, write L. E. Pratt, United Electric Controls Company, 85 School Street, Watertown 72, Mass.

TEMPERATURE SHOCK CHAMBER BY TENNEY ENGINEERING, INC. PROVIDES VERY FAST CYCLING

A new temperature shock chamber has been developed by Tenney Engineering, Inc., Union, N.J., for very rapid, automatic cycling of electronic components and small assemblies undergoing environmental tests.



This chamber is unique because it is a completely self-contained unit. There is no manual handling, no drawers to move and no removing test objects until the testing is completed.

Switching from hot to cold, in a temperature range of -85° to +425° F. takes only 10 seconds, and recovery time to the set point takes only 20 minutes. The entire operation is controlled with an automatic programmer.

A special defrosting arrangement permits low temperature operation for an indefinite period without the refrigeration coil icing up. This feature, according to Mr. Brown, assures maximum efficiency and guards against down time on the equipment.

The chamber incorporates Tenney's patented cascade condenser. It is 5 feet wide, 7 feet high and 8 feet deep. The stainless steel interior is heliarc welded and has work space of 45"x30"x55". It will do a complete test on as many as 25,000 transistors at one time.

Membership in IES

Several classes of membership are provided in the Institute of Environmental Sciences which parallel those of other societies, namely: Fellow, Honorary Fellow, Member, Associate Member, Student, Government Member, and Company Member. Requirements for the individual classes of membership have been established and will be available upon application for membership. All past members of SEE and IEE have automatically been assigned the member classification without further qualification. Fellows and Members are eligible to vote and hold office. Associate Members may vote but cannot hold office. Student, Government and Honorary Members do not vote or hold office.

APPLICATIONS

For further information regarding membership write to The Institute of Environmental Sciences, Box 191, Mt. Prospect, Illinois. Attention: Leon Carver, Vice President, Membership.

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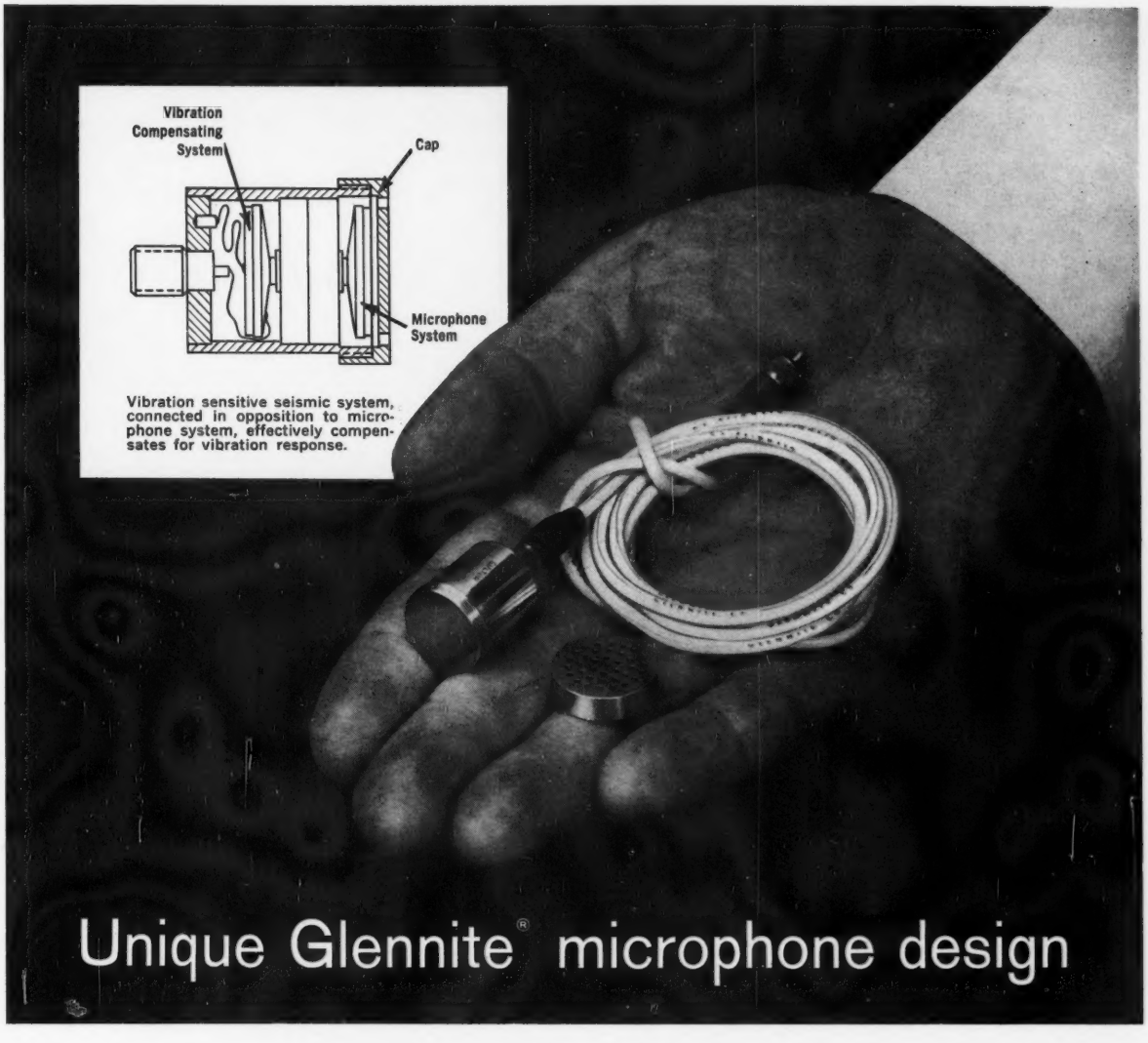
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Vibration sensitive seismic system, connected in opposition to microphone system, effectively compensates for vibration response.

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...cancels out vibration!

Gulton engineers use a unique vibration compensating design in this Glennite P-420M6 microphone resulting in maximum accuracy and reliability of high intensity sound measurements.

By the addition of a vibration sensitive seismic system, electrically connected in opposition to the microphone system, response of the microphone to vibration is virtually eliminated.

Output per "g" of vibration corresponds to less than 80 db sound pressure level (SPL)—permitting microphone to maintain a high signal to noise ratio in high vibration environments.

The P-420M6 incorporating the piezoelectric seismic systems is only $\frac{5}{8}$" in diameter, has wide dynamic range and excellent linearity. It is designed to operate in a missile environment with a ± .5 db response from −65° to +250°F.

For complete details and specifications, write Instrumentation Division, Gulton Industries, Inc.

SPECIFICATIONS

SPL Sensitivity (minimum):	0.5 mv minimum at 110 db (referred to .0002 dyne/cm²)
Range:	110 to 190 db SPL
Linearity:	Within ± 0.5 db of measured SPL over range indicated
Frequency Response:	10 cps to 3 KC ± 2 db 3 KC to 10 KC ± 3 db (parallel incidence)
Vibration Sensitivity Axial:	Equivalent to 80 db SPL at 1 g rms vibration
Temperature Range:	−65°F to +250°F, less than ± 1 db change from room ambient sensitivity

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- Easiest Access to Specimen and Instrumentation
- Minimum Wow and Drift Through High Inertia Design
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- Electrical Slip Rings
- Capacities to 15,000 G Pounds, 92 Inch Diameter
- 90° Specimen Rotation During Operation (Procedure I under MIL-E-5272A)—(Optional)
- Wave Guides for all Applications (Optional)
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- Hydraulic-Pneumatic Rotary Joints (Optional)

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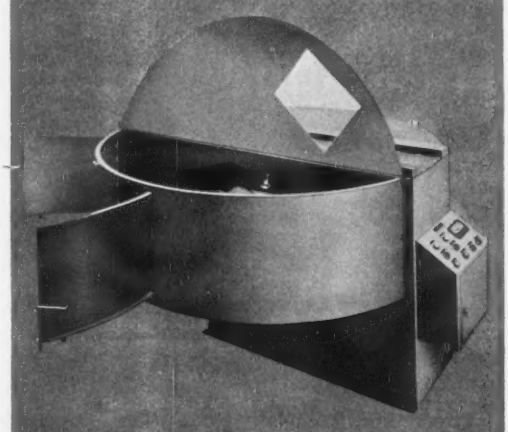
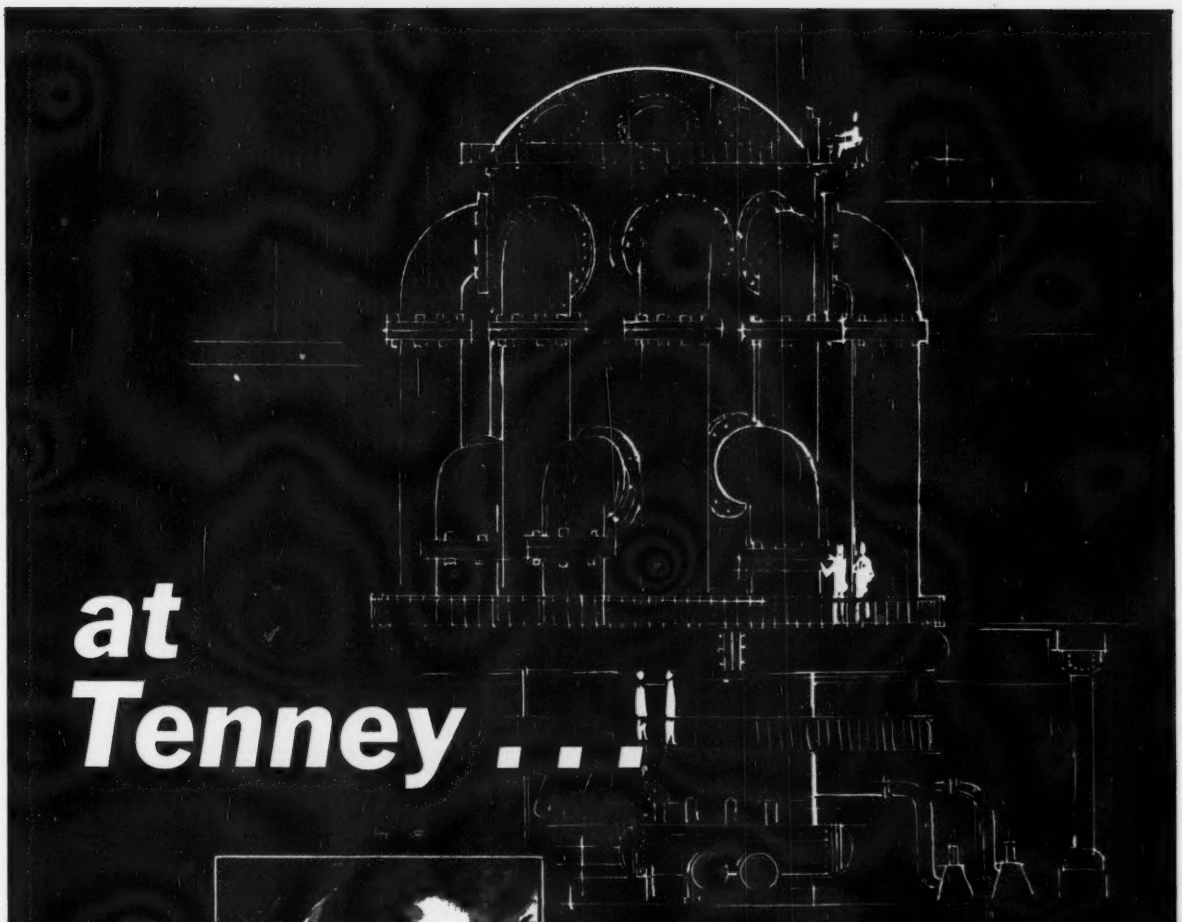


To meet your requirements for acceleration testing under MIL-E-5272 A Procedures I and II

RUCKER SERIES 10 AND 20 CENTRIFUGES ALSO AVAILABLE WITH CAPACITIES IN EXCESS OF 450,000 G POUNDS AND DIAMETERS TO 70 FEET



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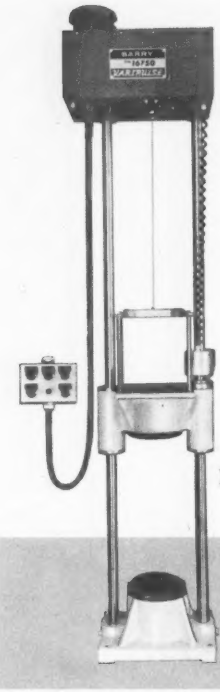
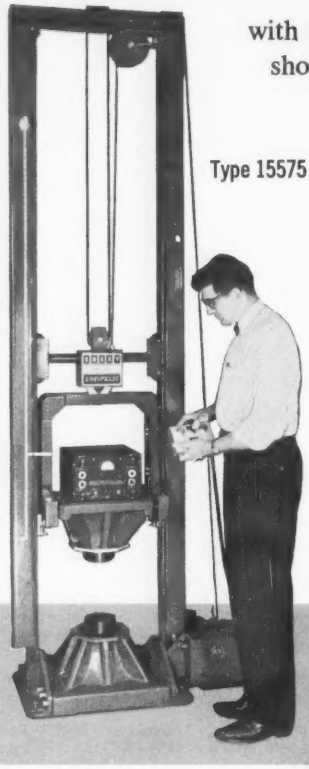
with BARRY VARIPULSE shock-testing machines is precise, safe, and simple.

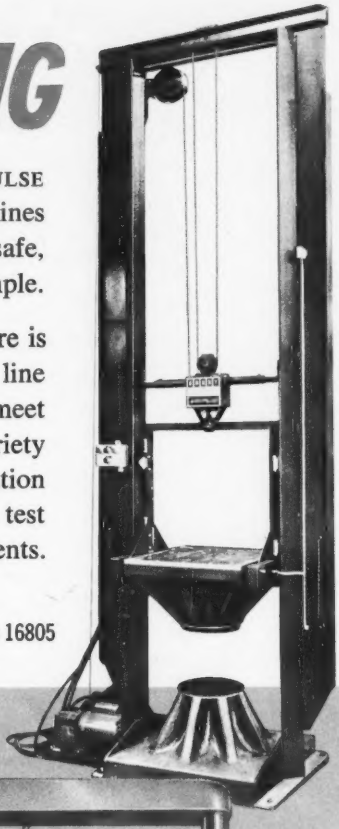
Here is a complete line to meet a wide variety of qualification or production test requirements.



Type 16750



Type 15575



Type 16805

- Gravity free-fall principle
- Half-sine, sawtooth, square waves
- Repeatable pulses
- Economical operation

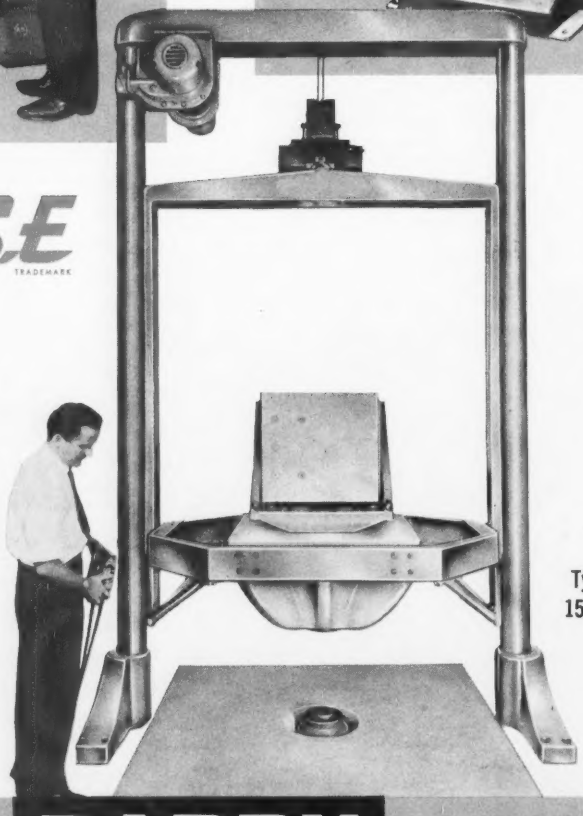
VARIPULSE

TRADEMARK

Type	Maximum capacity	Boundary parameters for half-sine pulses
16750	20 pounds 8" x 8" x 8"	From 1500g @ 0.5 m'sec. to 35g @ 30.0 m'sec.
15575	100 pounds 15" x 15" x 15"	From 1000g @ 1.0 m'sec. to 22g @ 65.0 m'sec.
16805	200 pounds 24" x 24" x 24"	From 1000g @ 1.0 m'sec. to 22g @ 65.0 m'sec.
15000	600 pounds 30" x 30" x 67"	From 500g @ 2.0 m'sec. to 12g @ 65.0 m'sec.

All Varipulse machines will produce sawtooth pulses per Ramo-Wooldridge spec. GM43.5-40

For details write for Bulletin 59-07 and mention specific machine of interest to you.



Type 15000

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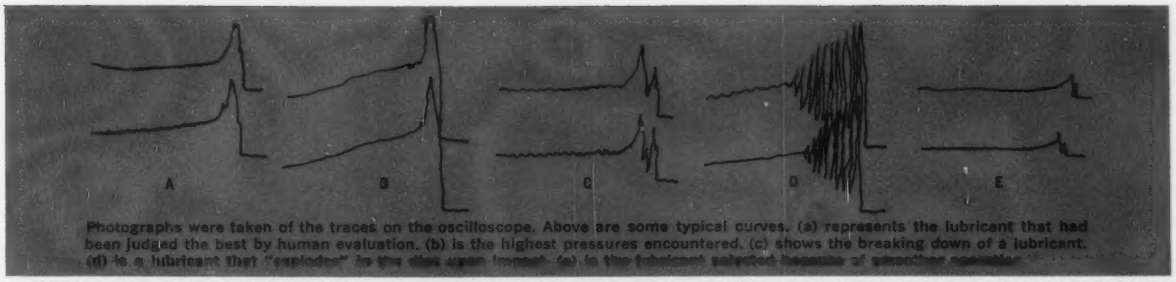
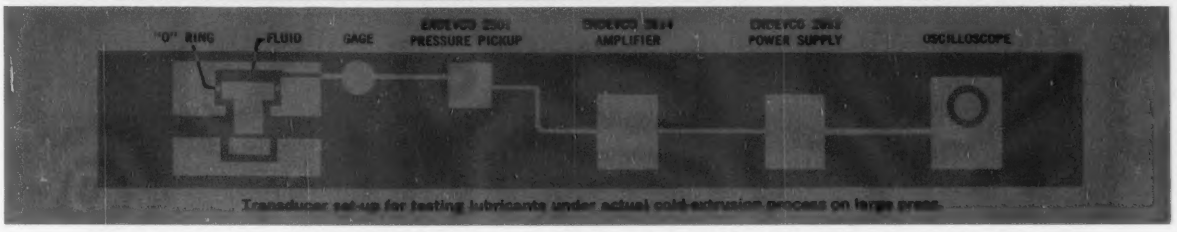


Photographs were taken of the traces on the oscilloscope. Above are some typical curves. (a) represents the lubricant that had been judged the best by human evaluation. (b) is the highest pressures encountered. (c) shows the breaking down of a lubricant. (d) is a lubricant that "exploded" in the dies upon impact. (e) is the lubricant selected because of smoother operation.



Transducer set-up for testing lubricants under actual cold-extrusion process on large press.

ENDEVCO TRANSDUCER

EXTENDS THE LIFE OF A HIGH-PRESSURE EXTRUSION PRESS

At its plant in Elgin, Illinois, Flexonics Corporation, manufacturers of flexible metal tubing and hose, employs a large press for the cold extrusion of metal parts. This press operates at high, critical pressures (up and beyond 300,000 psi). The key to its efficient operation and life span is the lubricant used.

Problem: The choice of lubricant was generally determined by the sound and feel of the press while in service. As extrusion problems became more complex, a better way of selecting the proper lubricant was needed.

Solution: Flexonics engineers hooked up an ENDEVCO PRESSURE PICKUP with an oscilloscope to compare the performance of lubricants under actual working conditions. Out of 20 lubricants tested, one proved to be superior, which had not been considered under the "sound and feel" method of evaluation. It is now being used exclusively. At the same time, the Endevco instrumentation divulged other valuable information as to correct press speed, and the optimum design of tools and dies. Endevco piezoelectric transducers and amplifiers are available for environmental, flight, shock, impact testing; design studies, control applications, and many others. Write for literature.

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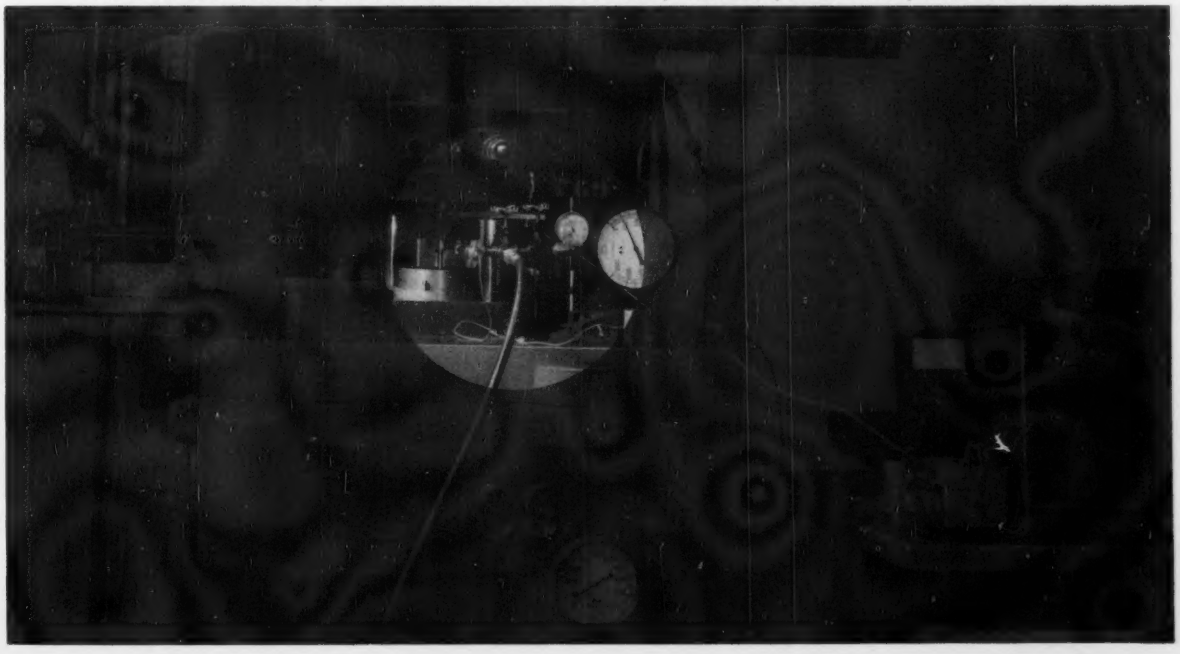

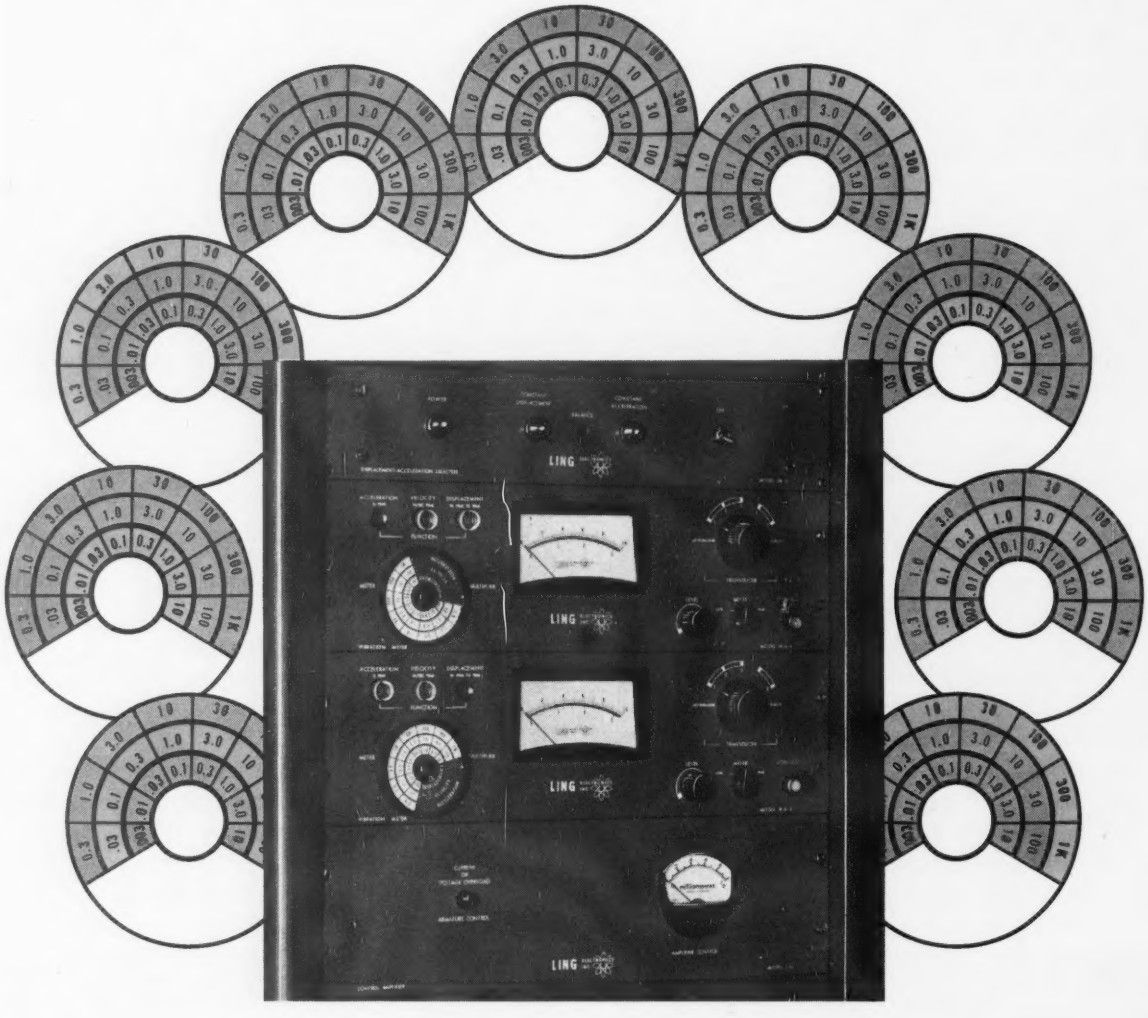

AUTOMATION IN VIBRATION–Vibration variations of 1000 to 1 automatically controlled by NEW LING S-14 SERVO

Ling introduces another advance in vibration testing—a new electronics servo system that offers a dynamic range of 60 db, plus remarkable accuracy and ease of control. This new variable response S-14 Servo System performs automatically, while frequency cycling with a sine-wave signal source. It simultaneously monitors any two values of acceleration, velocity or displacement, then automatically selects the larger as the controlling signal, and maintains it constant. Automatic thumpless transfer between the control functions takes place—you simply set the desired limits on the corresponding vibration meter. Reaction time is inversely proportional to frequency, and as a result, controlled levels of plus or minus 3% are attainable over a wide dynamic range. Like other Ling designs, the S-14 is flexible—the basic system can be expanded to handle 4 separate signals, or to permit automatic control from 3 or 4 control signals. For details, write Dept. 00 at our Anaheim address.

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